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RAW WATER QUALITY OF THE RED DEER RIVER WITH RESPECT TO THE OPERATION OF THE ANTHONY HENDAY WATER TREATMENT PLANT

Spring Runoff 1997

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EXECUTIVE SUMMARY

A water quality study was initiated on the Red Deer River to address water quality concerns experienced by the Anthony Henday Water Treatment Plant during periods of runoff. The study was designed to document longitudinal changes in water quality in the Red Deer River between the Dickson Dam and the City of Red Deer, and to evaluate the effects of contributions from the Little Red Deer and Medicine rivers on Red Deer River water quality during spring runoff.

Sampling started as soon as ice broke up in early April 1997 and continued until runoff subsided in May. Samples were analyzed for a range of water quality attributes including nutrients, bacteria, colour and odour.

The results of the monitoring indicate that during spring runoff 1997, the Little Red Deer and Medicine rivers contributed substantially to flows and materials transported in the Red Deer River. Downstream of the confluence with these tributaries, bacteria, nutrient, odour and colour levels were significantly higher than upstream and surface water quality guidelines were met less frequently. Red Deer River water quality was inferior at Innisfail compared to "below the dam", but it was not significantly different from water quality experienced further downstream at Red Deer.

The Little Red Deer and Medicine rivers are agricultural watersheds and it is probable that agricultural activities contribute bacteria, colour, odour and nutrients to these streams, particularly when best management practices are not in place. However, these contaminants are not specific to agriculture and natural sources are also likely contributors.

ACKNOWLEDGEMENTS

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Inorganic chemistry samples were analyzed at the Environmental Chemistry Laboratory under the supervision of Dr. R.D. Smillie (ARC, Vegreville). Bacterial samples were analyzed at the Provincial Health Laboratory under the supervision of E. Ashdon (Edmonton).

B. Halbig (Water Sciences Branch) provided assistance with data compilation and processing and with report preparation.

The report was reviewed by David Trew (Water Sciences Branch) and Peter Stevens.

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1.0 BACKGROUND

The Anthony Henday water treatment plant experiences recurrent water treatment problems, especially during spring runoff (Appendix A). The plant attributes these problems to contributions from agricultural runoff, in particular from the Medicine River and the Little Red Deer River. Little Buffalo Creek, which enters the Red Deer River upstream of the water treatment plant intake, receives domestic sewage from Innisfail and the Bowden penitentiary. This small creek may also contribute to the water treatment problems.

Water Management Division carried out an investigation during spring runoff of 1997 to:

1) document longitudinal changes in water quality of the Red Deer River between the Dickson Dam and the City of Red Deer; and
2) evaluate the effects of contributions from the Little Red Deer River, Medicine River and Little Buffalo Creek on Red Deer River water quality.

2.0 METHODS

2.1 WATER QUALITY SAMPLING PROGRAM

Water quality surveys were carried out in spring 1997 during spring runoff. Water quality sampling started as soon as ice broke up, and continued until runoff subsided. Grab samples were collected daily during peak runoff, then twice a week and once a week as flows declined.

Samples were tested for odour, colour, turbidity, suspended solids (NFR), total and dissolved phosphorus (TP and TDP), ammonia nitrogen (NH_3), nitrite+nitrate nitrogen (NO_2+NO_3), total Kjeldahl nitrogen (TKN), dissolved and particulate carbon (DOC, POC), and bacteria (total and fecal coliforms and *E. coli*).

Water chemistry samples were analyzed at the Environmental Chemistry Laboratory under the supervision of Dr. R.D. Smillie (ARC, Vegreville); bacterial samples were analyzed at the Provincial Health Laboratory under the supervision of E. Ashdon (Edmonton).

Table 1 identifies sampling sites, sampling period, and sampling frequency. Figure 1 provides a map of the study area and shows the location of water quality sampling sites and flow gauging stations.

Continuous flow data are recorded at several of the water quality sampling sites, including the Red Deer River d/s Dam, the Red Deer River at Red Deer City, the Little Red Deer River at the Mouth, and Medicine River near Eckville. Average daily flows were calculated by Hydrology Section (Water Sciences Branch) for the Red Deer River near Innisfail, and the Medicine River near the mouth. There was insufficient information to estimate average daily flows from Little Buffalo Creek.

2.2 DATA ANALYSIS

2.2.1 Instream Concentrations

Concentrations measured in the streams are indicative of the water quality experienced by the water treatment plant.

Data are summarized in two types of graphs. Time series plots (Figures 2-1 to 2-16) show individual data points by site and depict changes in concentrations over time. They allow visual comparisons of temporal trends among sites. Box and Whisker plots (Figures 3-1 to 3-16) represent the median (central horizontal bar), interquartiles (box) and extremes (whiskers), and summarize all data for each site. They allow visual comparisons among sites.

Water quality is evaluated by comparing concentrations or levels measured in the samples with Canadian Water Quality Guidelines (CCME 1997) and Alberta Ambient Water Quality Guidelines (AEP 1992). Guidelines specify safe levels for various uses such as the protection of aquatic life, irrigation, livestock watering and recreation. Guidelines for drinking water do not apply to raw water supplies (CCME 1997); they have been used in this study to illustrate the need for water treatment. The frequency with which concentrations comply with guidelines is expressed as a percentage for each site. An indication of the severity or degree of non-compliance (i.e., how much larger the measured concentration is than the guideline) is provided in the box and whisker plots where, when guidelines exist, they have been plotted on the graph.

To determine if differences among sites were statistically significant, the Kruskal-Wallis test (e.g., Elliott 1977), a one-way analysis by ranks, was used as a non-parametric alternative to the parametric analysis of variance. The choice of a non-parametric test was justified by the relatively low and variable number of data points per site and by the difficulties of meeting requirements for parametric tests. When differences among sites were significant (significance level 95% or greater) a multiple range test (Experiment-wise Kruskal-Wallis test) was applied to define which pairs of sites were significantly different (significance level: 95% or greater). Tests were performed using the statistical software from WQ Hydro (Aroner 1994). Two groups of sites were tested. The first group consisted of three sites on the Red Deer River (i.e., below the dam, at Innisfail and at Red Deer); the second group consisted of tributary sites (i.e., Little Red Deer River, Medicine River at Eckville and at mouth and Little Buffalo Creek). Test results on the first site group allow for an evaluation of longitudinal trends among Red Deer River sites; test results on the second group help determine which tributary contributes the highest concentrations.

2.2.2 Mass Load and Flow-weighted Mean Concentrations (FWMC)

Mass loads describe the amount of material which travel beyond a sampling point; they can help pinpoint sources of water quality problems. However, mass loads can be greatly influenced by discharge. FWMC standardize loads for flow and describe contributions per unit volume (e.g., mg/L), thereby facilitating comparisons among streams of different size.

Mass loads were calculated for the three Red Deer River sites and for the Little Red Deer and Medicine rivers at the mouth. Loads were not calculated for Little Buffalo Creek because flow data were not available. Mass load was calculated with version 4.5 of "FLUX" (Environmental Laboratory, Concord Massachusetts 1995). The IJC method (Method #3) developed by the International Joint Commission was used to perform calculations.

FWMC is part of the FLUX output. FWMC is calculated by dividing the mass load estimate for a given period of time by the total flow volume for that period of time.

3.0 RESULTS

3.1 SPRING RUNOFF 1997

Although some snowmelt occurred in late March 1997, most of the melt started on April 17, 1997. As a result of the snowmelt there was a rapid increase in discharge in the Red Deer River and its tributaries (Figure 2-1). In the Little Red Deer River basin, spring melt started about two weeks earlier than in the Medicine River. During peak flows, more water was contributed by the Little Red Deer River and especially by the Medicine River than by the Dickson Dam outflow (Figure 3-1). Although flow data are not available for Little Buffalo Creek, field observations suggest that its contributions to the flows in the Red Deer River were comparatively very small.

Flows recorded in April 1997 were high compared to long-term records (Data from Water Survey Canada and AEP). Average daily flows in the Little Red Deer River exceeded the upper 95% for the period of record 1961-1996. At Red Deer, average daily flows ranged between the 75 and 95th percentile of post impoundment flows recorded at that site. There are no long-term flow records on the Medicine River near the mouth with which to compare flows in April.

River flows are an important consideration in water quality studies.

- Generally speaking, the higher the flow is, the higher mass transport is.

- Higher flows can reduce the concentration changes due to point source discharges (i.e., because of dilution). In this study, the Little Red Deer River and Medicine River can be considered as point sources to the Red Deer River even though they themselves receive non-point source inputs. However, their flows were also high in April and since they contribute much of the flow in the Red Deer River, dilution should not have attenuated their effects on the Red Deer River.

Year-to-year differences in runoff and local snowmelt patterns can result in year-to-year differences in overland runoff and material transport to surface waters. As a consequence, the degree of impacts from non-point sources on surface water quality can vary from year-to-year. Such variability can not be captured in a single spring runoff study.

3.2 TEMPORAL CHANGES IN WATER QUALITY

Temporal changes in water quality are shown in Figures 2-2 to 2-16.

Several water quality attributes underwent a sharp increase in concentration as flows increased; as flows subsided, concentrations declined again. This was particularly noticeable for fecal coliforms, total coliforms, *E. coli*, NFR, turbidity, TKN, TN, TP and PP. At most mainstem and tributary sites, peak concentrations were recorded on April 17, when flows were highest.

At Red Deer River sites concentrations for all water quality attributes tested were noticeably lower below the dam than at Innisfail or Red Deer City.

For tributaries, the highest peak concentrations during peak flows were, in many instances, recorded at the Little Red Deer River site.

- Highest odour threshold levels were recorded in the Little Red Deer River, but well before (April 1, 1997) the main melt occurred and just before (April 3) the highest odour threshold levels were recorded at Innisfail. This suggests that the Little Red Deer River might have contributed most to odour problems at that time.

- Highest colour levels were measured in Little Buffalo Creek (April 8 and 10) when the Red Deer River at Innisfail was also experiencing high colour.

- Highest concentrations of TKN, NH_3, NO_2+NO_3, and TDP were also recorded in Little Buffalo Creek in May when the Bowden penitentiary and Innisfail were discharging their effluents. High TP and PP were also recorded around April 17 in that creek.

3.3 BOX AND WHISKER PLOTS AND STATISTICAL SIGNIFICANCE TESTING

Box and Whisker plots are shown in Figure 3-2 to 3-16 and results of the Kruskal-Wallis test are shown in Table 2.

3.3.1 Comparison of Water Quality at Sites on the Red Deer River

Results were consistent for all water quality attributes tested. In all instances median levels recorded 0.5 km below the Dickson Dam were significantly lower than levels recorded in the Red Deer River near the water treatment plant intake at Innisfail and at Red Deer City. However concentrations measured at Innisfail and at Red Deer City were not significantly different.

The Box and Whisker plots provide a visual illustration of such differences.

3.3.2 Comparisons of Water Quality at Tributary Sites

Patterns of differences among tributary sites differed for the various water quality attributes analyzed.

- Median levels of *E. coli*, total coliforms, NFR, tubidity, DOC, and ammonia did not differ significantly among the four tributary sites.
- In Little Buffalo Creek, median fecal coliform counts and colour were lower, but TP and NO_2+NO_3 were higher than in the Little Red Deer and Medicine rivers.
- Median odour, particulate carbon and total nitrogen levels were lower in the Little Red Deer River than in the Medicine River near the mouth.

Box and whisker plots provide a visual illustration of these differences.

3.4 COMPLIANCE WITH SURFACE WATER QUALITY GUIDELINES

Levels of *E. coli*, total coliforms, fecal coliforms, NFR, colour, turbidity, NO_2+NO_3 and ammonia measured at sites on the Red Deer River and at tributary sites were compared with Canadian Water Quality Guidelines (CCME 1997) for drinking water, recreation, and protection of aquatic life. Alberta Interim Ambient Guidelines were used to evaluate odour, TP and TN levels. Non-compliance is expressed as the percentage of the total number of samples analyzed which did not comply with guidelines (Table 3). Again, it is recognized that guidelines for drinking water do not apply to raw water supplies; they are used here to illustrate the need for water treatment.

Compliance with surface water quality guidelines in the Red Deer River generally decreased in downstream direction. However, even below the dam there was a high level of non-compliance with guidelines for bacteria and turbidity.

- Below the dam, drinking water guidelines were exceeded in all of the fecal coliform and turbidity samples and in 45% of the total coliform samples.
- At Red Deer, all samples exceeded drinking water guidelines for these variables and also for colour. In addition, some samples (11%) exceeded guidelines for fecal coliforms and all samples exceeded Alberta guidelines for phosphorus.
- Compliance level at Innisfail was somewhat intermediate with about 90% of the fecal coliform samples being non-compliant for drinking water and phosphorus guidelines and all samples being in compliance with fecal coliform guidelines for recreation.

All tributary sites were 100% non-compliant with drinking water guidelines for total and fecal coliforms, colour and turbidity and with Alberta guidelines for TP. Furthermore, 17% of the samples taken from Buffalo Creek exceeded ammonia guidelines for the protection of aquatic life.

3.5 MASS LOADS AND FLOW-WEIGHTED MEAN CONCENTRATIONS (FWMC)

Estimates of mass loads for various constituents are presented in Table 4. For most variables (i.e., *E. coli*, total coliforms, fecal coliforms, NFR, colour, odour, TKN, NO_2+NO_3, NH_3, TN, TP, and TDP), the sum of loads from the Little Red Deer and Medicine rivers to the Red Deer River below the dam yields a value which is very close to the load estimate calculated for the Red Deer River at Innisfail. This is an indication that the main contributors to this Red Deer River load are these two rivers. The Little Red Deer and Medicine rivers contribute considerably more than the Red Deer River below the dam to the loads at Innisfail.

Loads in the Medicine River were generally higher than in the Little Red Deer River because of the higher flows in the Medicine River. When FWMC are considered (Table 5), it becomes apparent that, per unit flow, both rivers were supplying similar loads of various forms of nutrients. However, FWMC of bacteria and NFR were greater in the Little Red Deer River.

4.0 CONCLUSIONS

Results from water quality monitoring carried out it spring (April) 1997 in the Red Deer River and its major tributaries upstream of Red Deer City indicate that:

- There are significant changes in water quality in the Red Deer River between the Dickson Dam and Innisfail. These changes involve significant increases in bacteria, nutrients, odour and colour levels. There are also notable increases in non-compliance with surface water quality guidelines.

- Differences in water quality in the Red Deer River at Innisfail and City of Red Deer were not statistically significant in April 1997. However, the degree of non-compliance with surface water quality guidelines was highest at the City of Red Deer.

- The Little Red Deer River and Medicine River contributed much of the flow and materials measured in the Red Deer River at Innisfail during spring runoff.

- Mass load contributions from Little Buffalo Creek could not be evaluated because of lack of flow data; based on observations of modest flows at the time of sampling, loads are expected to be low, despite elevated concentrations of many attributes.

- Flow-weighted mean concentrations which standardize for flow, indicate that colour, odour and nutrients contributed by both streams were similar, but that bacterial contributions from the Little Red Deer River tended to be higher.

Although these results are representative of conditions which existed in April 1997, it is recognized that different runoff conditions could result in somewhat different longitudinal trends in the Red Deer River or in a different relative influence of tributaries on the Red Deer River. Agricultural activities can contribute bacteria, colour, odour and nutrients to surface waters, particularly when best

management practices are not in place. However, it must also be recognized that not all contributions from the Little Red Deer and Medicine rivers are necessarily attributable to agricultural activities. Indeed, spring runoff is typically a time of year when water quality is inferior as a result of material movement from land to streams or re-suspension from the stream channel. Further site-specific investigations can resolve this question.

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Table 1. Sampling of the Red Deer River near Innisfail (spring runoff 1997).

SAMPLING SITE	SAMPLING PERIOD	NUMBER OF SAMPLES
RDR d/s Dam	March 26 to May 1	12
RDR u/s Buffalo Creek	May 20 to May22	2
RDR near Innisfail WTP Intake	March 26 to May 22	15
RDR near Red Deer City WTP Intake	April 1 to May 1	10
Little Red Deer River near Mouth	March 27 to May 1	16
Medicine River near Mouth	April 17 to May 1	9
Medicine River near Eckville	April 17 to May 1	5
Little Buffalo near Mouth	March 31 to May 22	12

Table 2. Summary of results of Kruskal-Wallis test and Multiple Range Test (Experiment-wise Kruskal-Wallis test).

1. Comparison of Water Quality at Red Deer River Sites

Test Sites:
0.5 km d/s Dam = 1
at Innisfail WTP Intake = 2
at Red Deer City WTP Intake = 3

WQ Variable Tested	Kruskal-Wallis Test Significance level	Multiple Range Test (P<0.05)
E. coli	99%	1<2, 1<3, 2=3
Total coliforms	99%	1<2, 1<3, 2=3
Fecal coliforms	99%	1<2, 1<3, 2=3
NFR	99%	1<2, 1<3, 2=3
Odour	99%	1<2, 1<3, 2=3
Colour	99%	1<2, 1<3, 2=3
Turbidity	99%	1<2, 1<3, 2=3
PC	99%	1<2, 1<3, 2=3
DOC	99%	1<2, 1<3, 2=3
TKN	99%	1<2, 1<3, 2=3
(NO_2+NO_3)-N	99%	1<2, 1<3, 2=3
NH_3-N	99%	1<2, 1<3, 2=3
TN	99%	1<2, 1<3, 2=3
TP	99%	1<2, 1<3, 2=3
PP	99%	1<2, 1<3, 2=3

2. Comparison of Water Quality at Tributary Sites

Test Sites:
Little Red Deer River = 1
Medicine River at Mouth = 2
Medicine River at Eckville = 3
Little Buffalo Creek = 4

WQ Variable Tested	Kruskal-Wallis Test Significance level	Multiple Range Test (P<0.05)
E. coli	NS	
Total coliforms	NS	
Fecal coliforms	95%	1>4, 2>4, 3>4
NFR	NS	
Odour	95%	1<2
Colour	99%	1>4, 2>4, 3>4
Turbidity	NS	
PC	99%	1<2, 1<3, 1<4
DOC	NS	
TKN	95%	1>3, 2>3, 3<4
(NO_2+NO_3)-N	95%	1<4,2<4, 3<4
NH_3-N	NS	
TN	99%	1<2, 1<4, 2>3, 3<4
TP	95%	1<4, 2<4, 3<4
PP	NS	

Table 3. Non-compliance with surface water quality guidelines in the Red Deer River and its tributaries during spring runoff 1997.*

SAMPLING SITE		100632 E.COLI no./100mL	36002 COLIFORMS TOTAL no./dL	36012 COLIFORMS FECAL no./dL	10401 NFR mg/L	2001 ODOUR T.O.N.	2024/2021 COLOUR TRUE Rel. Units	2074 TURBIDITY NTU	7105/7110 NO_3+NO_2 mg/L	TN mg/L	15421/15406 TP mg/L	7562/7561 NH_3 mg/L
Detection Limit:		**L4**	**L4**	**L4**	**L2/L1**	**L1**	**L3/L1**				**L0.001**	**L0.005**
Guidelines for:	**Drinking Water:**	**NG**	**10/100 mL**	**0/100 mL**	**NG**	**NG**	**15 TCU**	**1 NTU**	**10**	**NG**	**NG**	**NG**
	Aquatic Life:	**NG**	**NG**	**NG**	**bkgr+10 mg/L or 10%**	**NG**	**NG**	**NG**	**NG**	**NG**	**NG**	**T/pH dependent**
	Recreation:	**400**	**NG**	**400**	**NG**	**NG**	**NG**	**NG**	**NG**	**NG**	**NG**	**NG**
	ASWQ:	**NG**	**NG**	**NG**	**NG**	**no>8**	**NG**	**NG**	**NG**	**1**	**0.05**	**NG**
RDR 0.5 km below Dam	No. of Samples:	11	11	11	11	11	11	11	11	11	11	11
	% Non-compliance: Drink	-	45	100	-	-	0	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	0	-
RDR nr. Innisfail Intake	No. of Samples:	11	11	11	10	10	10	10	10	10	10	10
	% Non-compliance: Drink	-	91	91	-	-	90	90	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	90	-
RDR nr. Red Deer City Intake	No. of Samples:	9	9	9	10	10	10	10	10	9	10	10
	% Non-compliance: Drink	-	100	100	-	-	100	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	11	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	100	-
Little RDR nr. Mouth	No. of Samples:	16	16	16	15	15	15	15	15	9	15	15
	% Non-compliance: Drink	-	100	100	-	-	100	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	100	-
Medicine R. nr. Mouth	No. of Samples:	8	8	8	9	9	9	9	9	9	9	9
	% Non-compliance: Drink	-	100	100	-	-	100	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	100	-
Medicine R. u/s Eckville	No. of Samples:	5	5	5	5	5	5	5	5	9	5	5
	% Non-compliance: Drink	-	100	100	-	-	100	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	0
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	100	-
Little Buffalo Cr. nr. Mouth	No. of Samples:	12	12	12	12	12	12	12	12	12	12	12
	% Non-compliance: Drink	-	100	100	-	-	100	100	0	-	-	-
	PAL	-	-	-	-	-	-	-	-	-	-	17
	REC	0	-	0	-	-	-	-	-	-	-	-
	ASWQ	-	-	-	-	0	-	-	-	0	100	-

* Refer to Box and Whisker plots (Figures 3-1 to 3-16) for an evaluation of the amplitude of non-compliance.
NG = No Guideline

Table 4. Estimate of average daily load in the Red Deer River and its tributaries upstream of Red Deer during spring runoff 1997.

SAMPLING SITE	*E .Coli* No./day	Tot. Coliforms No./day	Fecal Coliforms No./day	NFR kg/d	Odour T.O.N./d	Colour Rel. Units/d	PC kg/d	DOC kg/d	TKN kg/d	NO_2+NO_3 kg/d	NH_3 kg/d	TN kg/d	TDP kg/d	TP kg/d
Red Deer River														
0.5 km below Dam	49,364	1,142,271	53,386	10,208	2,369	13,895	1,472	5,406	533	313	128	845	13	41
at Innisfail	7,822,789	309,006,849	7,849,701	2,107,284	36,395	756,392	65,258	91,896	18,206	3,258	2,816	21,464	1,502	4,459
at Red Deer City WTP Intake	5,144,378	198,855,726	40,298,795	2,285,588	18,837	735,478	89,106	88,435	18,014	3,126	2,883	21,141	1,445	4,546
Tributaries														
Little Red Deer River at Mouth	3,104,441	131,908,329	4,171,230	976,597	7,887	162,783	43,240	23,968	6,413	900	751	7,313	294	1,704
Medicine River at Mouth	3,840,671	221,758,712	3,951,208	884,602	23,045	719,353	36,986	3,123	15,283	2,908	2,568	18,191	1,615	3,444

Table 5. Estimate of flow-weighted mean concentration (FWMC) in the Red Deer River and its tributaries upstream of Red Deer during spring runoff 1997.

SAMPLING SITE	*E. Coli* No./100 mL	Tot. Coliforms No./100 mL	Fecal Coliforms No./100 mL	NFR mg/L	Odour T.O.N.	Colour Rel. Units	PC mg/L	DOC mg/L	TKN mg/L	NO_2+NO_3 mg/L	NH_3 mg/L	TN mg/L	TDP mg/L	TP mg/L
Red Deer River														
0.5 km below Dam	2	46	2	4.1	0.959	5.629	0.596	2.19	0.215	0.126	0.051	0.342	0.005	0.016
at Innisfail	80	3164	80	215.817	3.727	77.465	6.682	9.411	1.864	0.333	0.288	2.198	0.153	0.456
at Red Deer City WTP Intake	50	1965	398	225.877	1.861	72.684	8.806	8.739	1.78	0.308	0.284	2.089	0.142	0.449
Tributaries														
Little Red Deer River at Mouth	108	4609	145	341.295	2.746	56.888	15.111	8.376	2.241	0.314	0.262	2.555	0.102	0.595
Medicine River at Mouth	49	2835	50	113.122	2.946	91.99	4.729	10.418	1.954	0.371	0.328	2.326	0.206	0.44

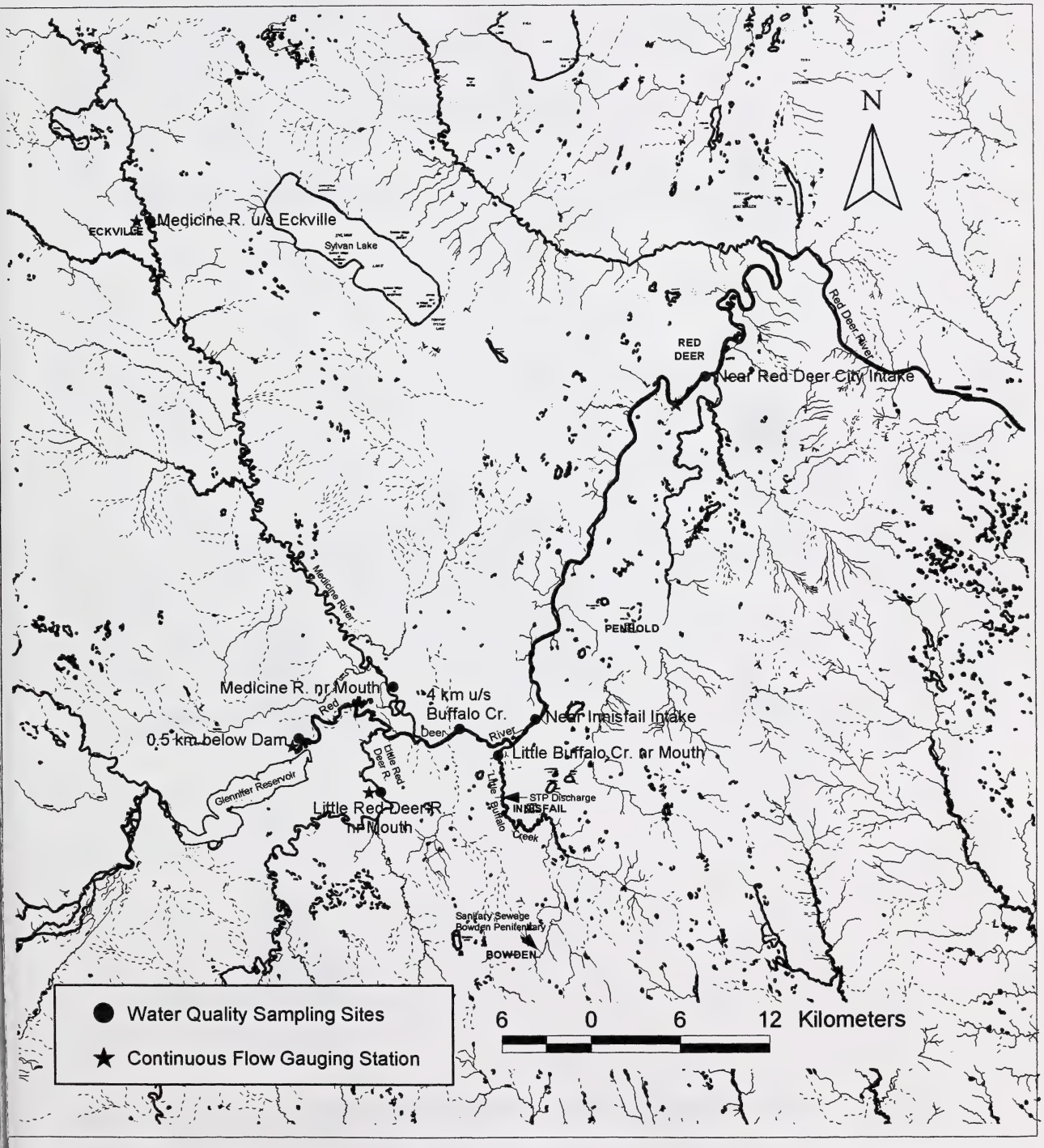

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Figure 1. Location of sites sampled during spring runoff on the Red Deer River, 1997.

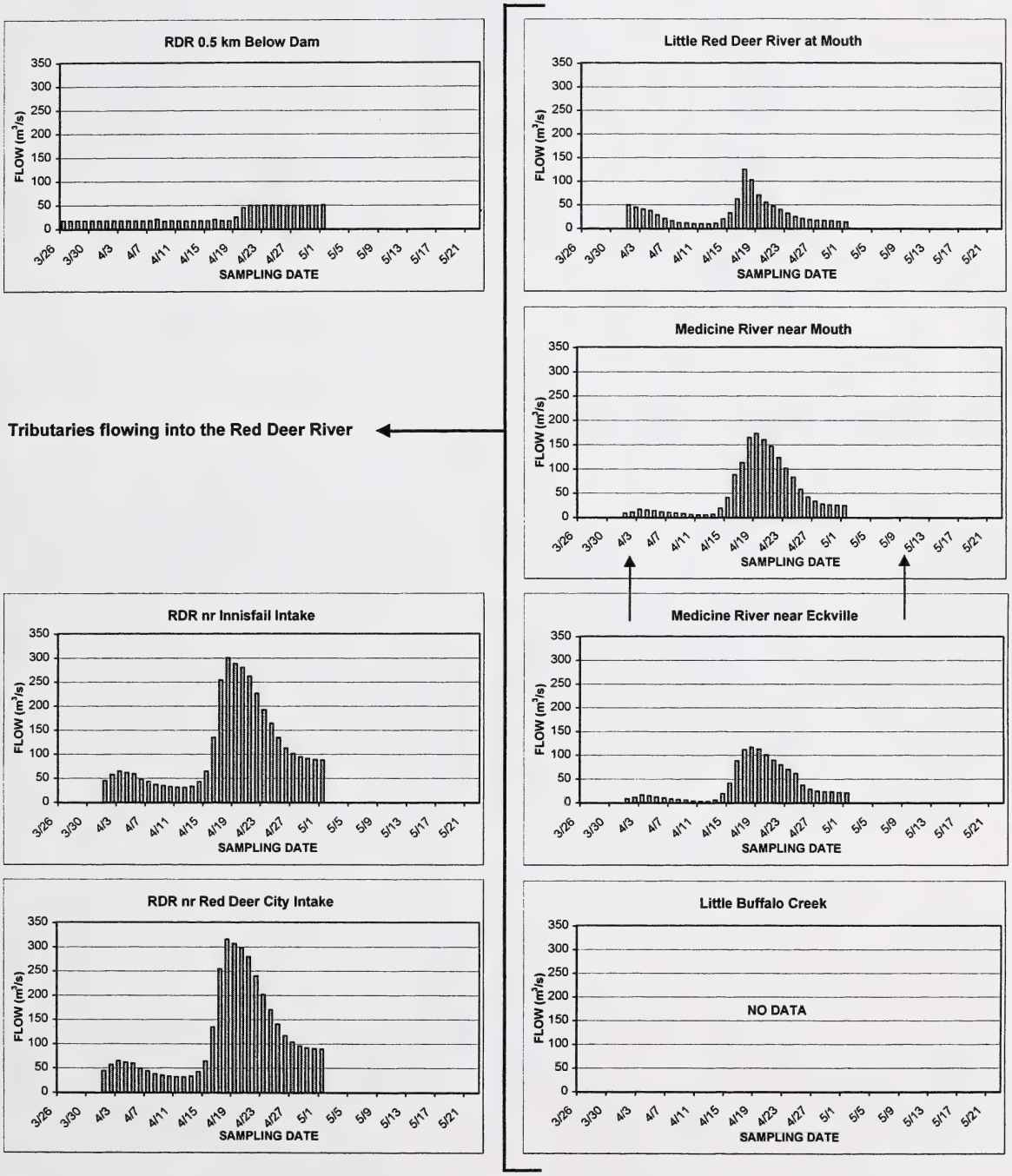


Figure 2-1. Average daily flow in the Red Deer River and its tributaries during spring runoff, 1997.

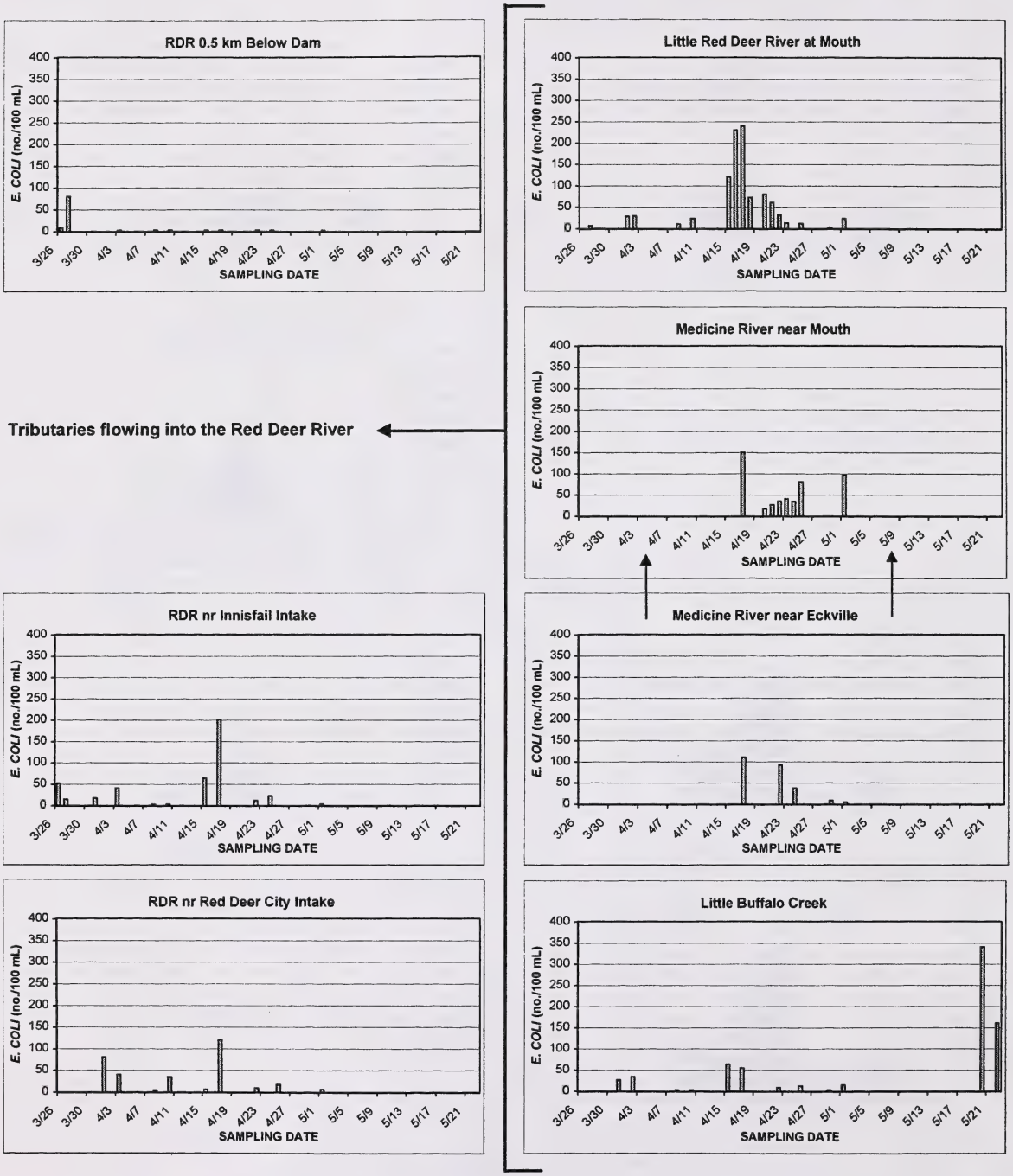


Figure 2-2. *E. coli* counts in the Red Deer River and its tributaries during spring runoff, 1997.

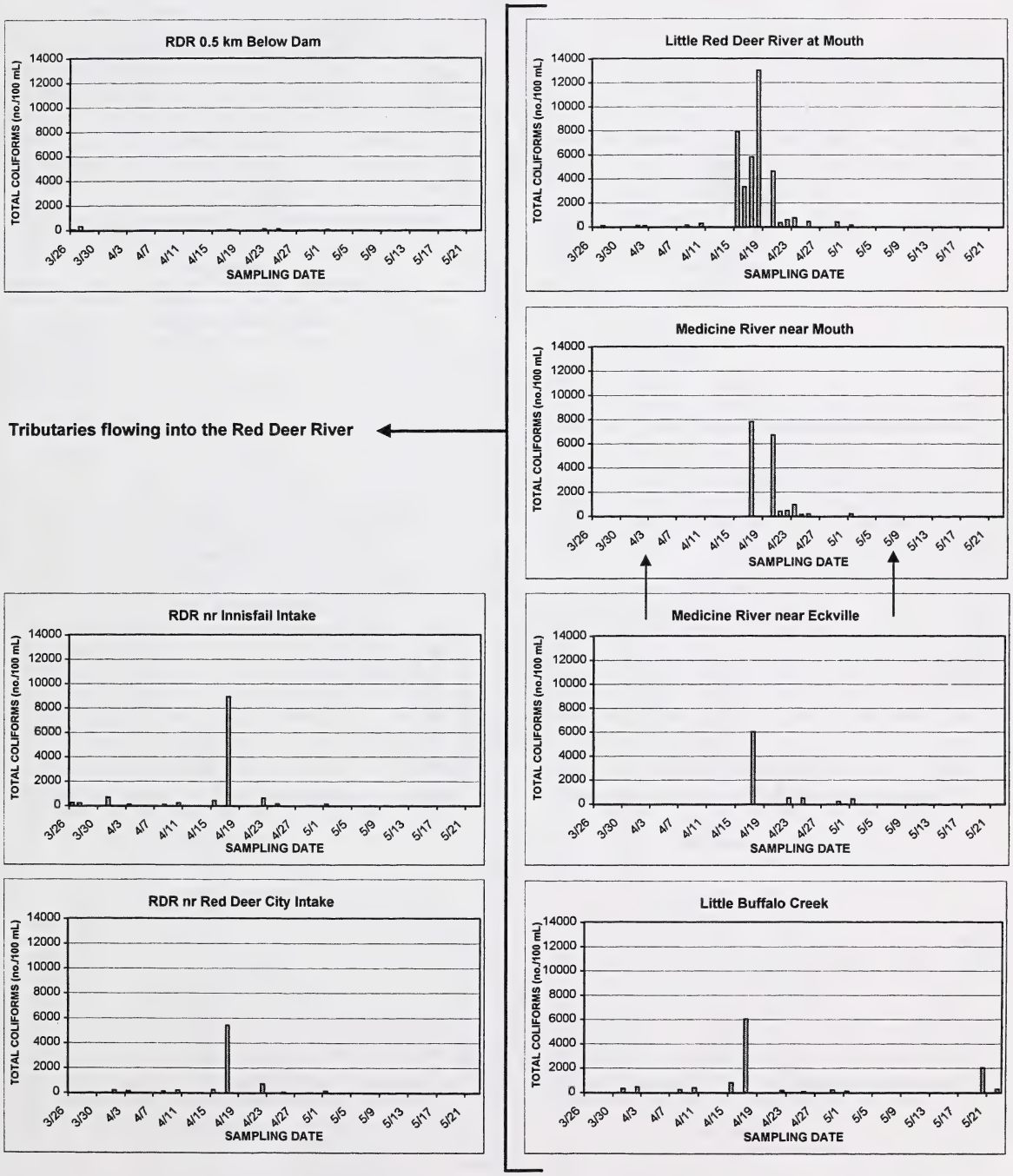


Figure 2-3. Total coliform counts in the Red Deer River and its tributaries during spring runoff, 1997.

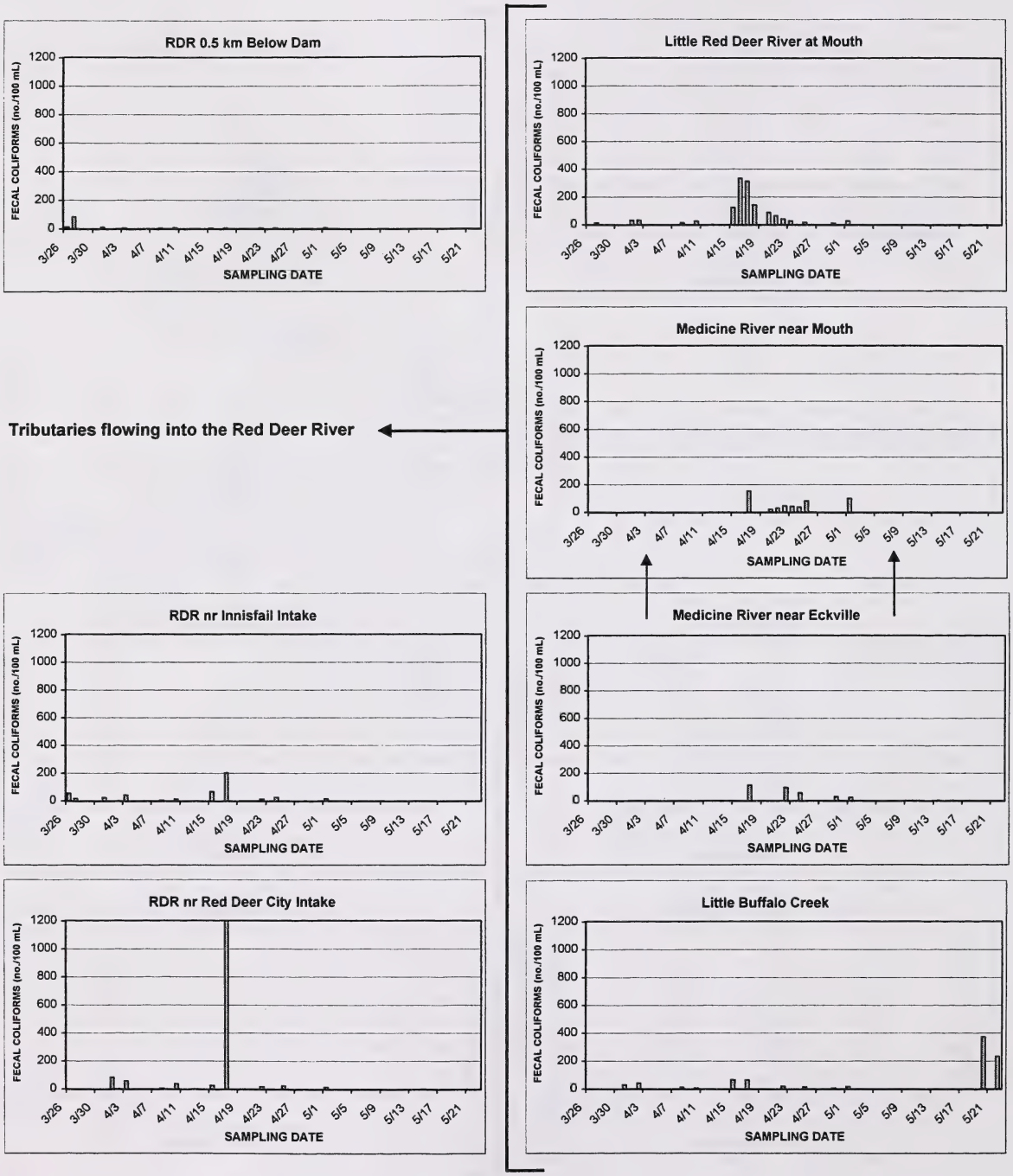


Figure 2-4. Fecal coliform counts in the Red Deer River and its tributaries during spring runoff, 1997.

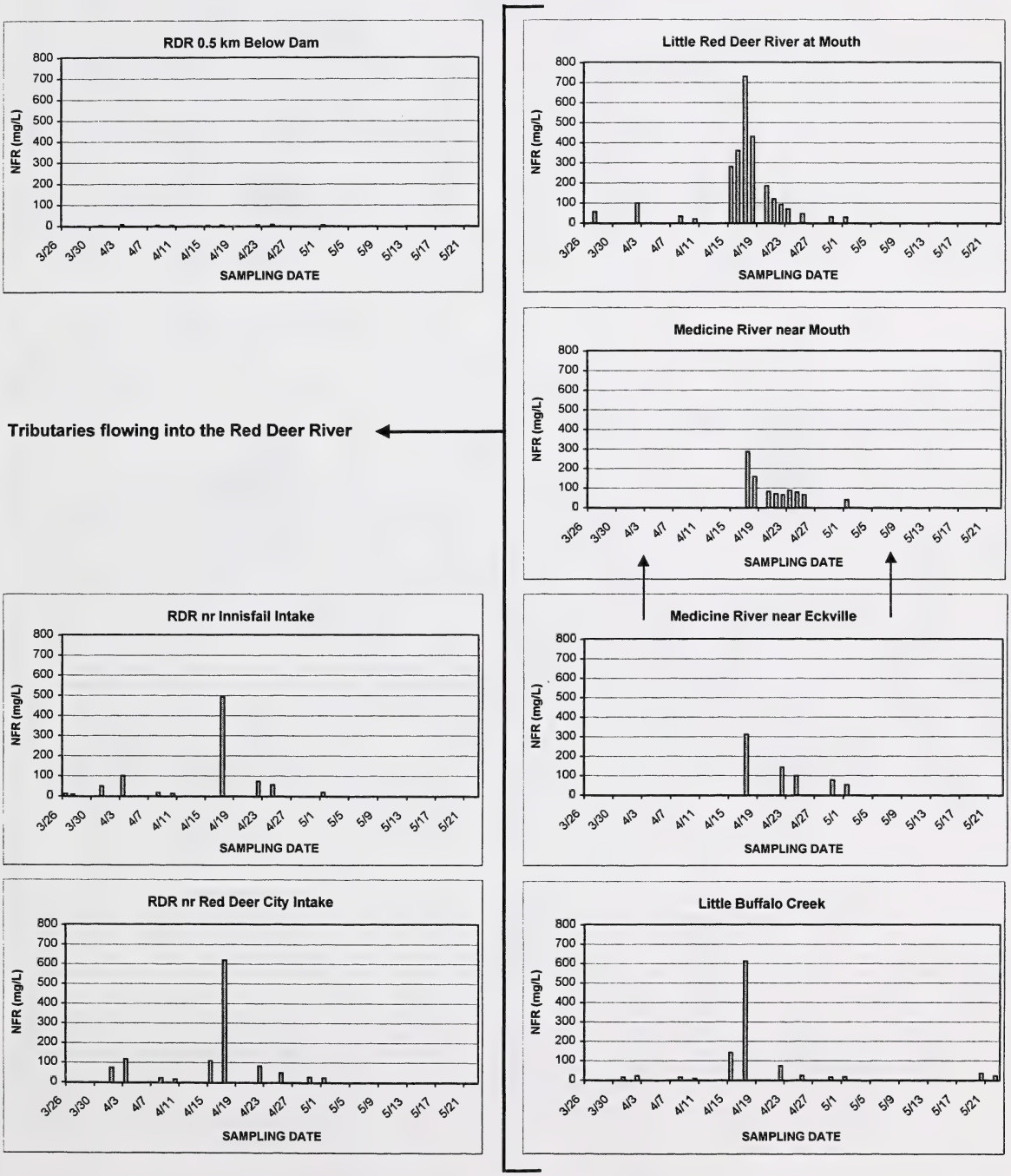


Figure 2-5. Non-filterable residue in the Red Deer River and its tributaries during spring runoff, 1997.

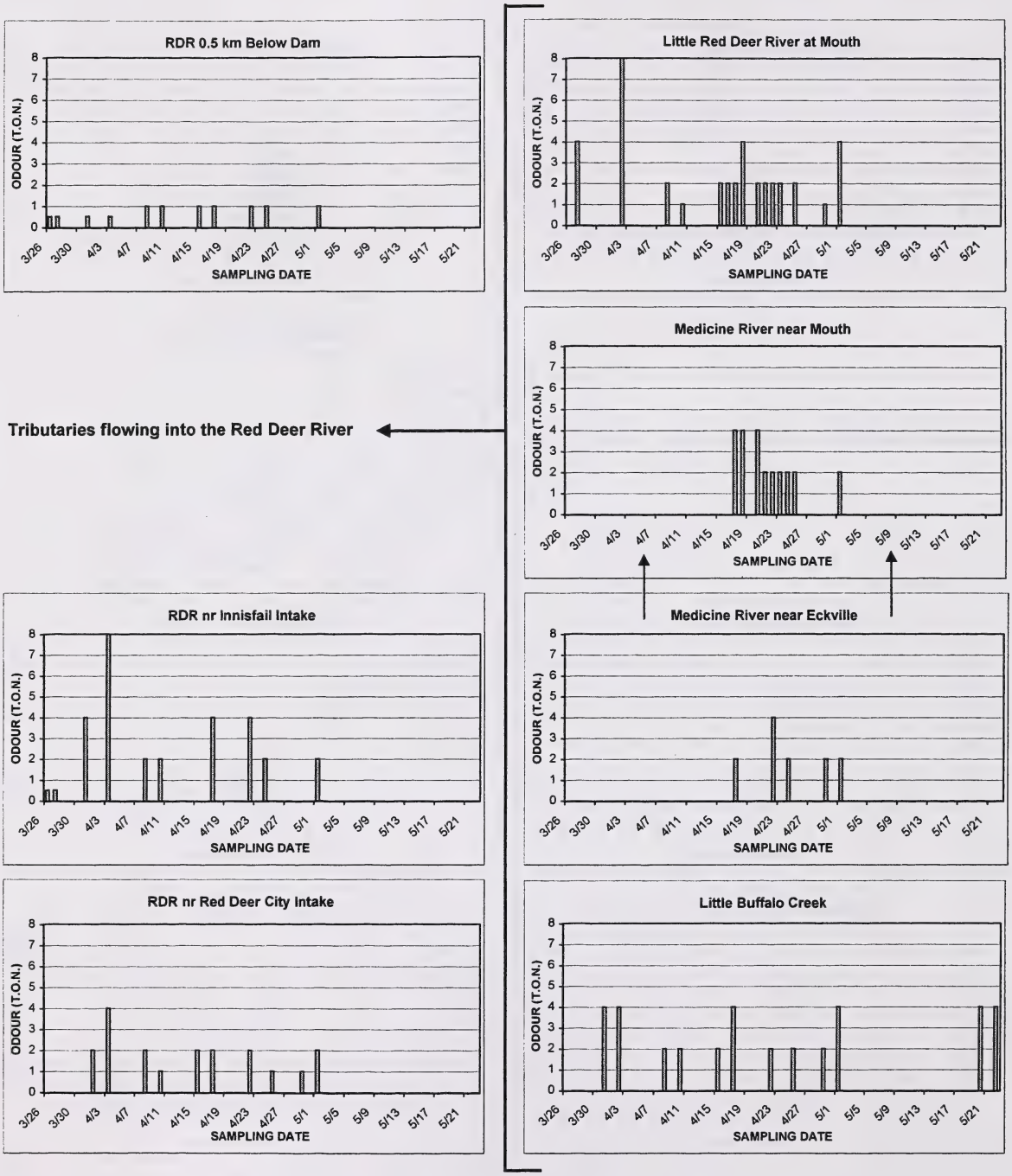


Figure 2-6. Threshold odour in the Red Deer River and its tributaries during spring runoff, 1997.

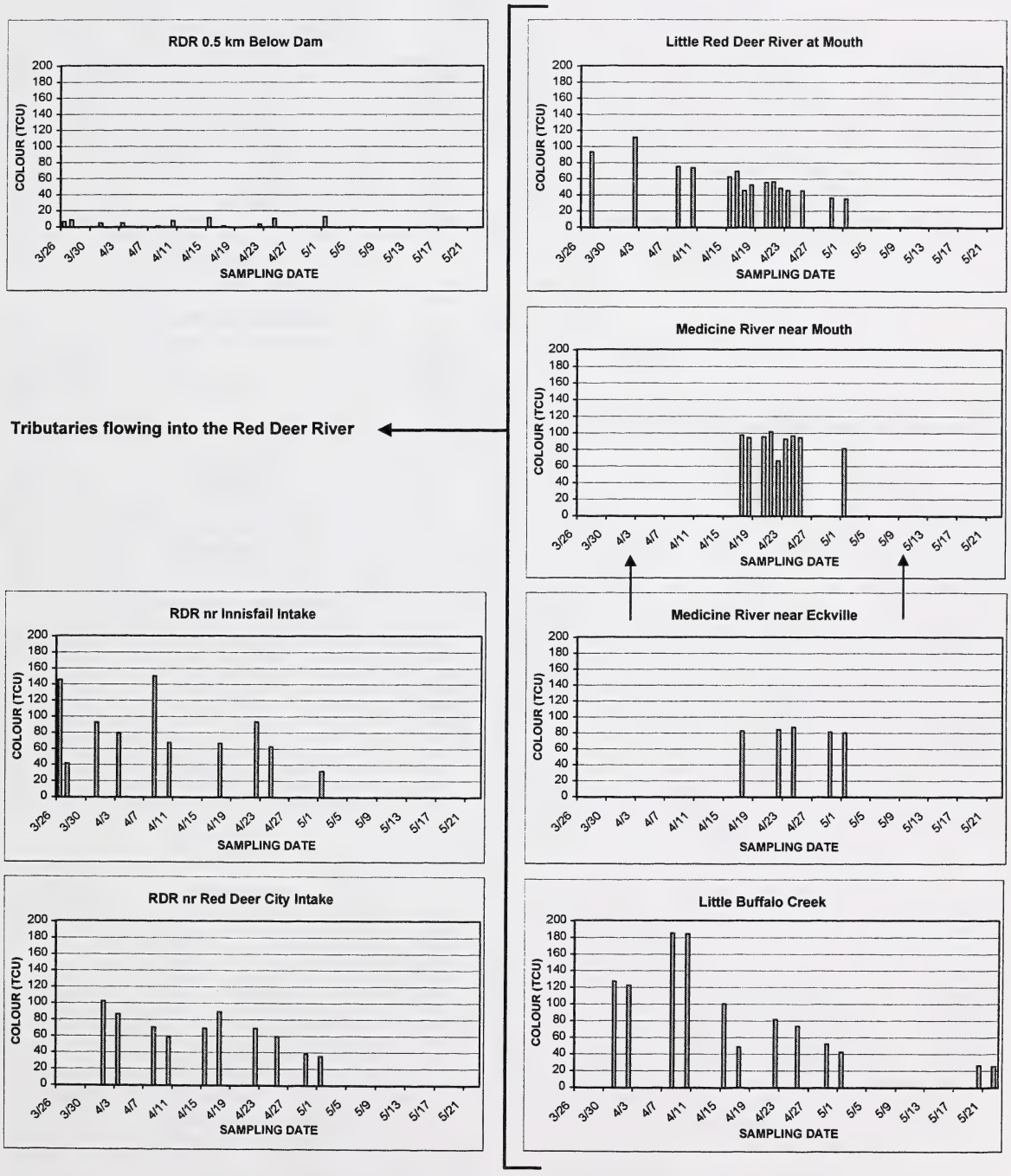


Figure 2-7. True colour in the Red Deer River and its tributaries during spring runoff, 1997.

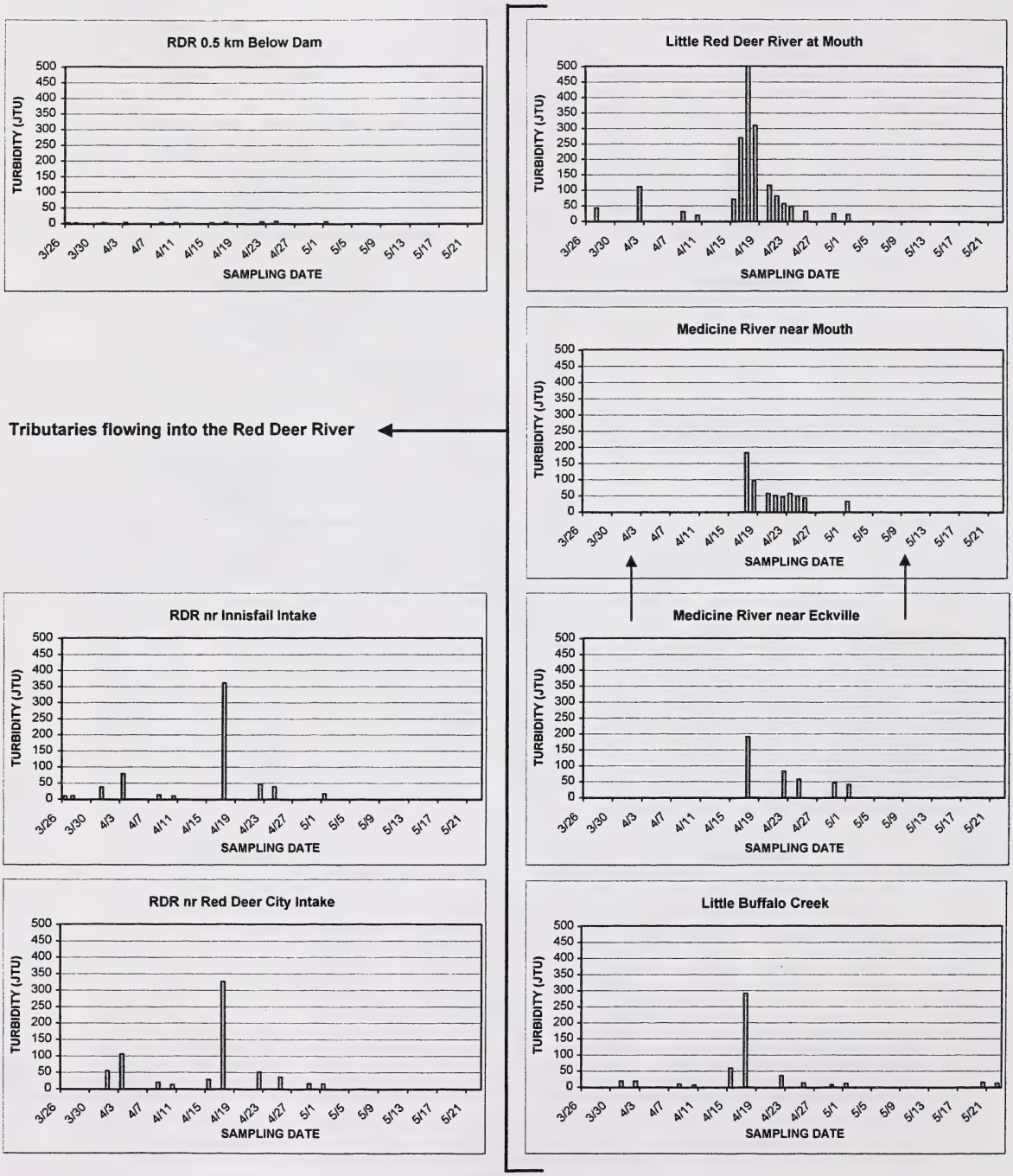


Figure 2-8. Turbidity in the Red Deer River and its tributaries during spring runoff, 1997.

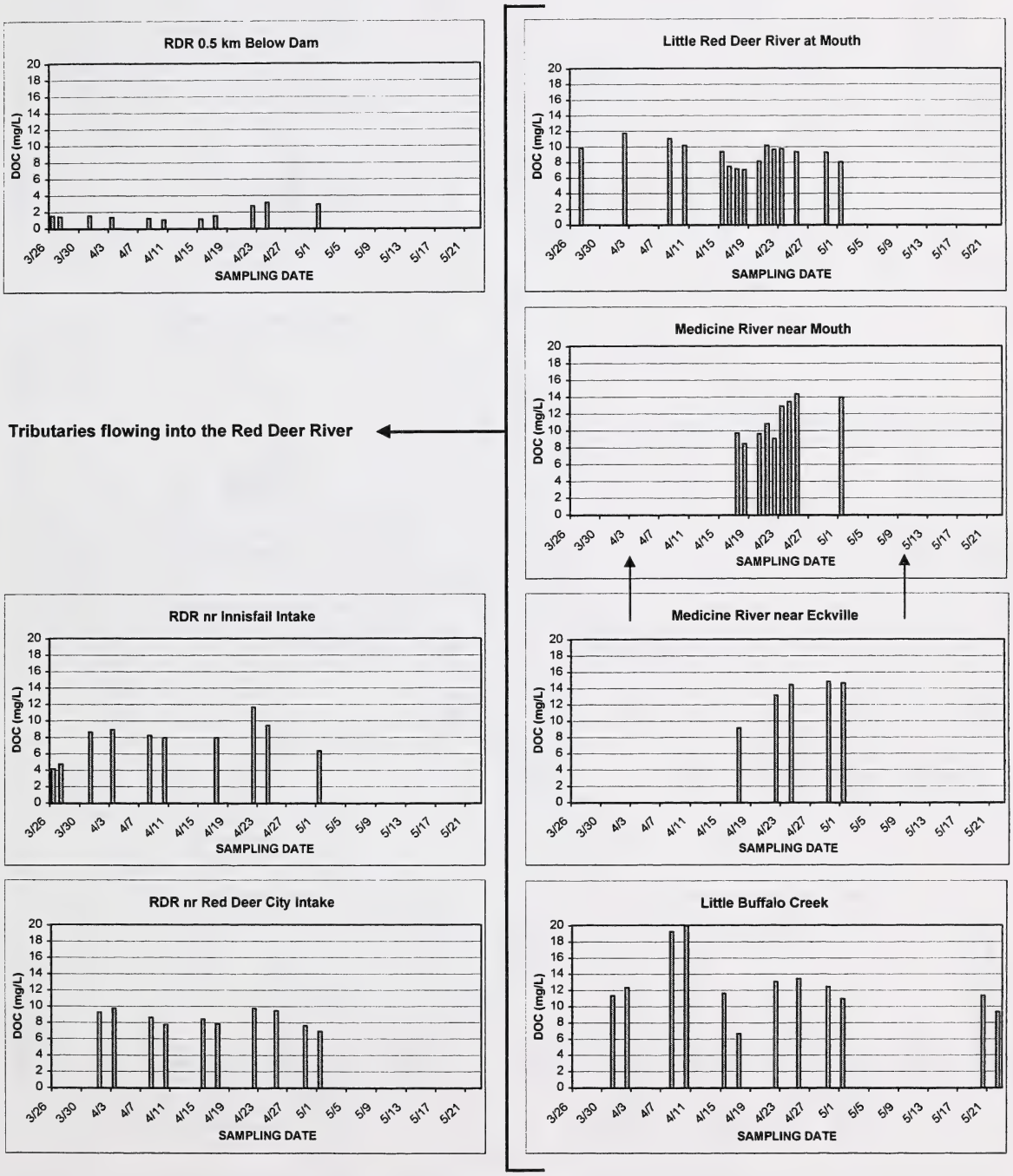


Figure 2-9. Dissolved organic carbon in the Red Deer River and its tributaries during spring runoff, 1997.

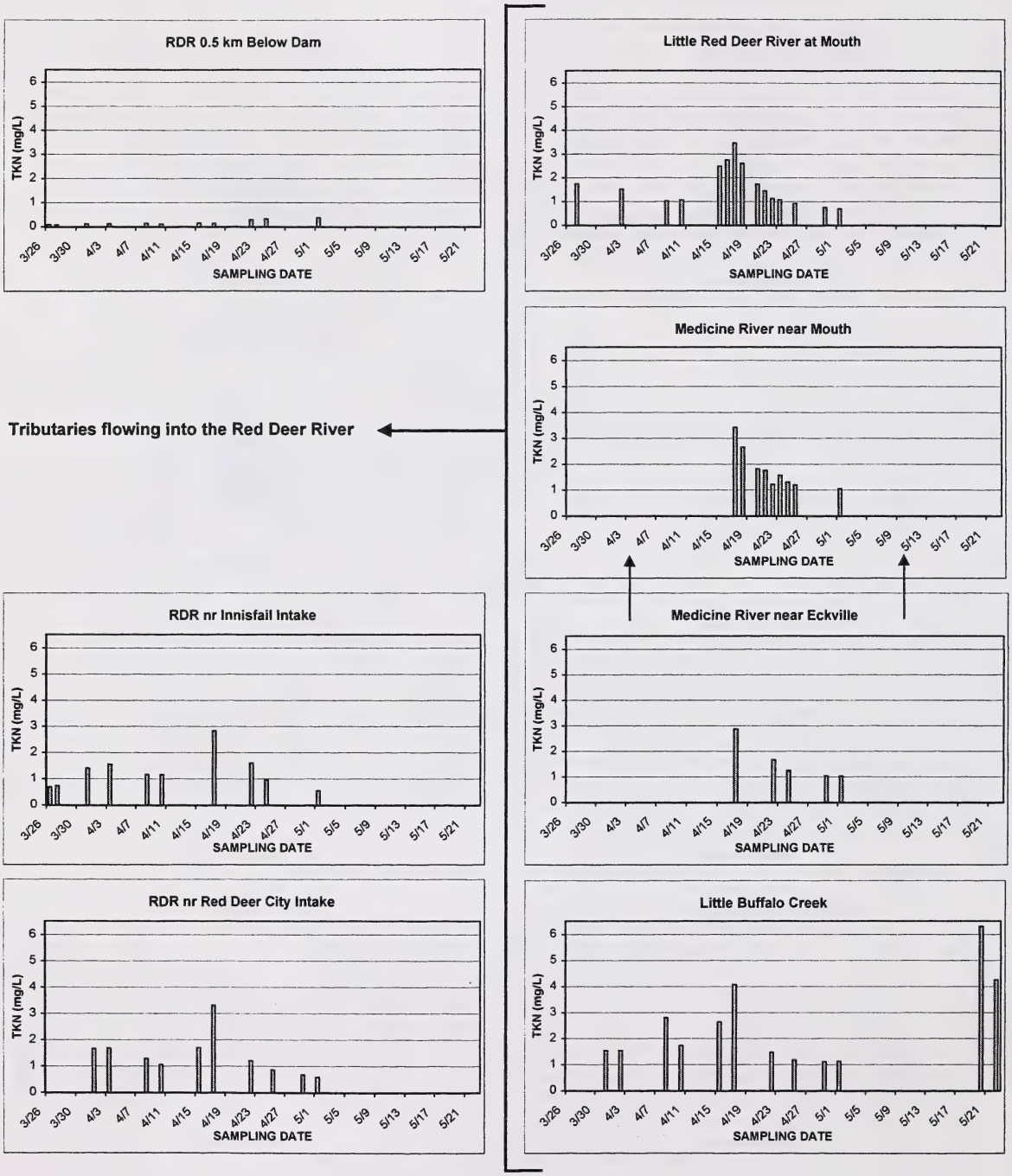


Figure 2-10. Total Kjeldahl nitrogen in the Red Deer River and its tributaries during spring runoff, 1997.

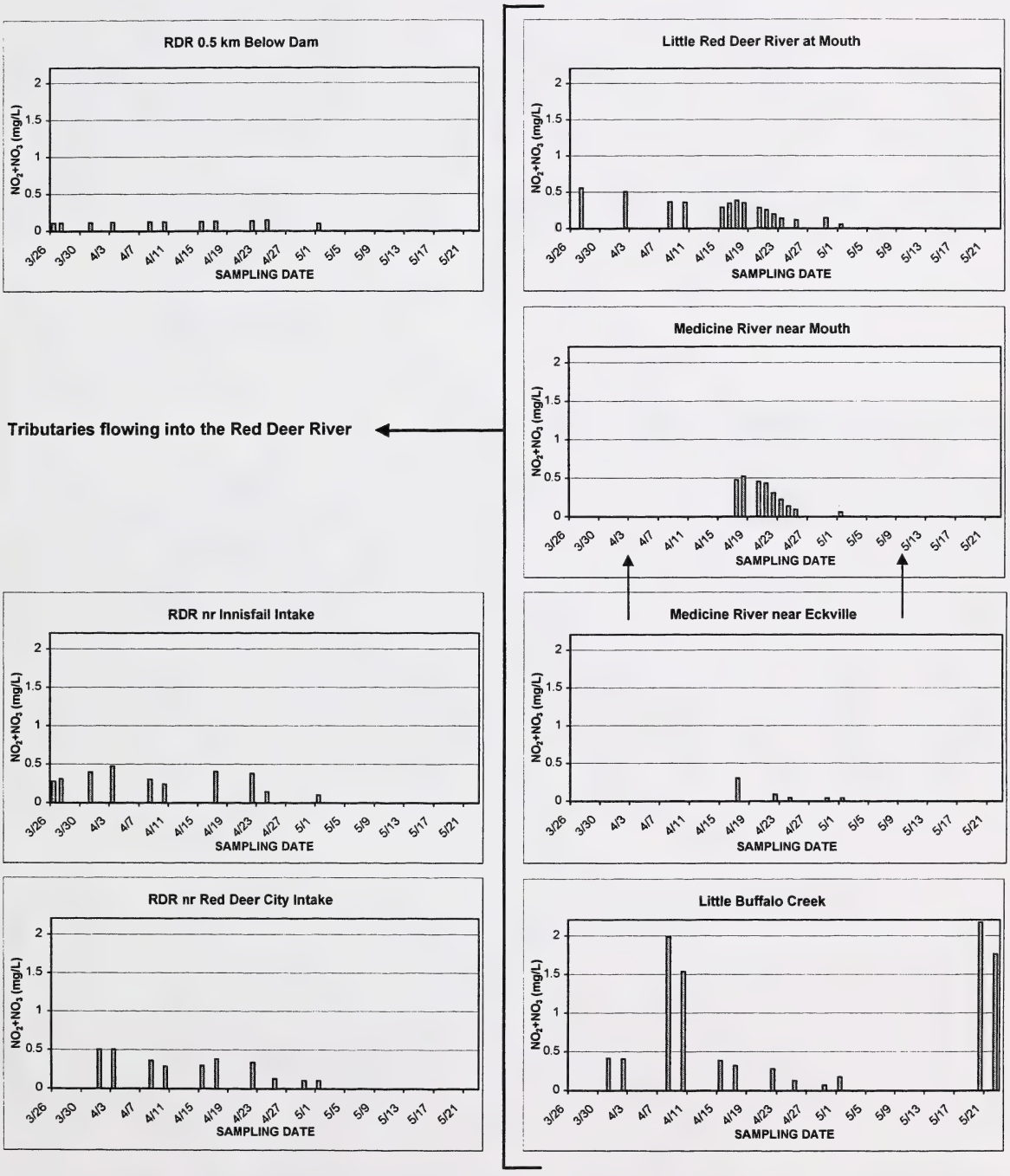


Figure 2-11. Nitrite+nitrate nitrogen in the Red Deer River and its tributaries during spring runoff, 1997.

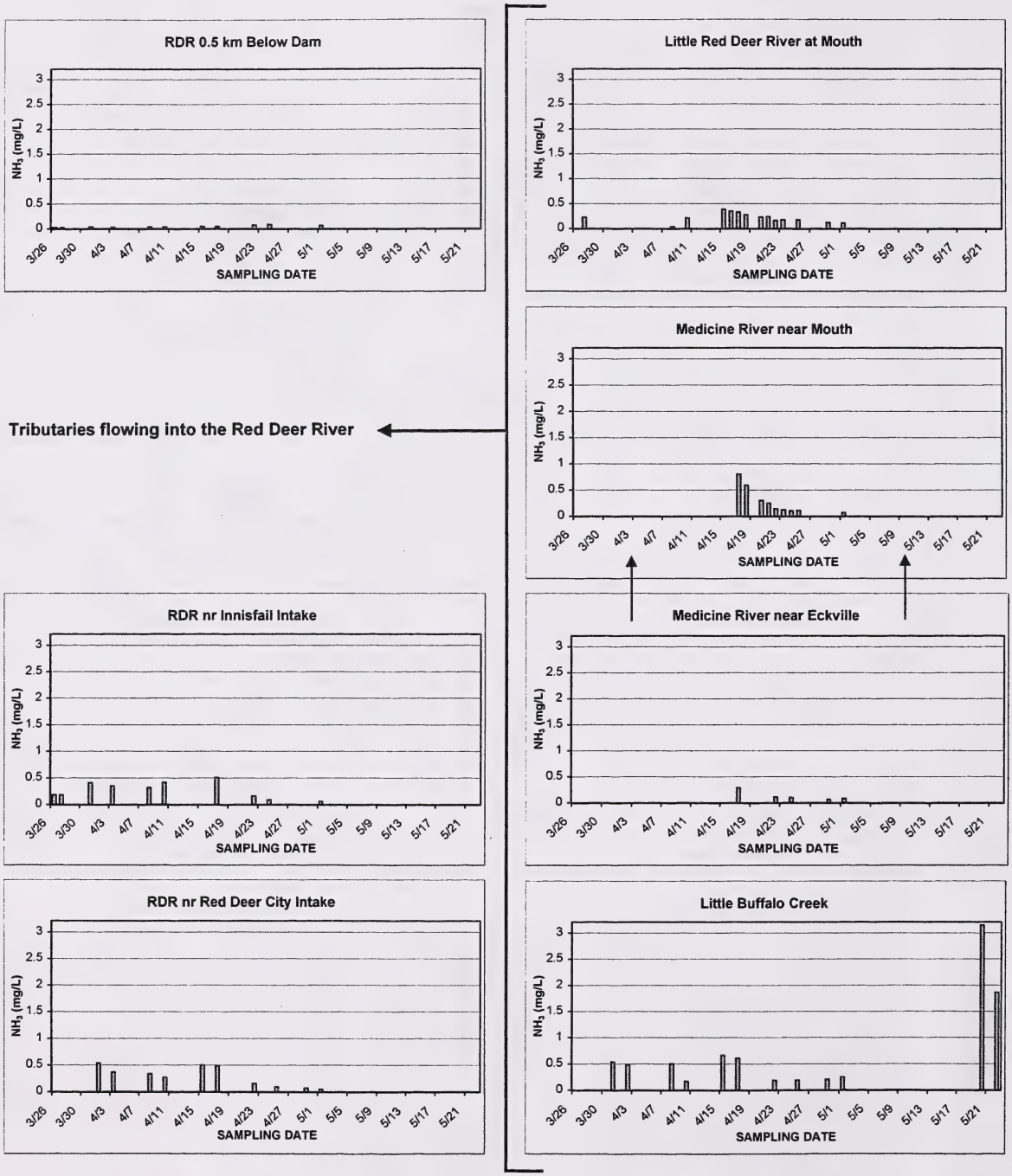


Figure 2-12. Total ammonia nitrogen in the Red Deer River and its tributaries during spring runoff, 1997.

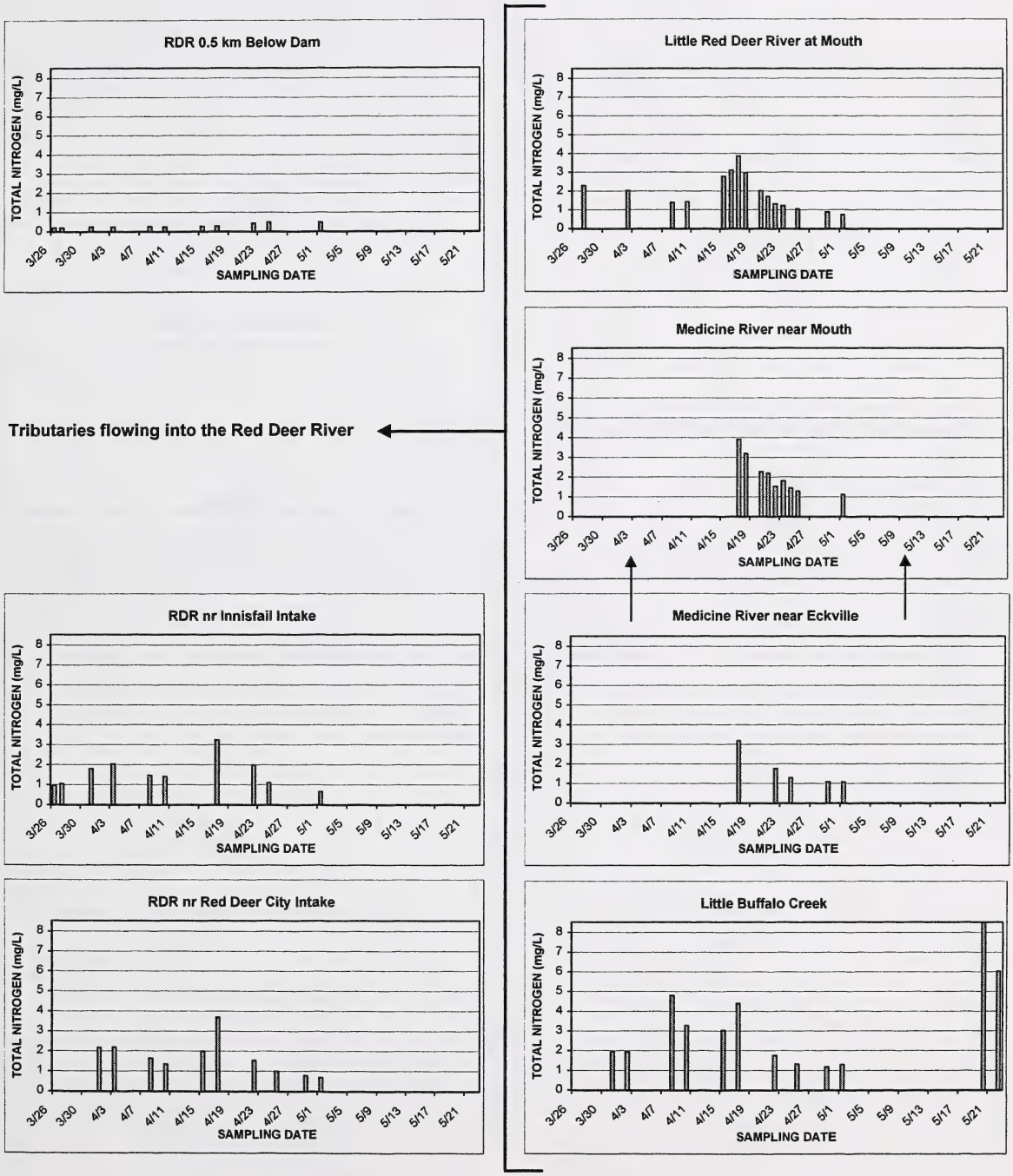


Figure 2-13. Total nitrogen in the Red Deer River and its tributaries during spring runoff, 1997.

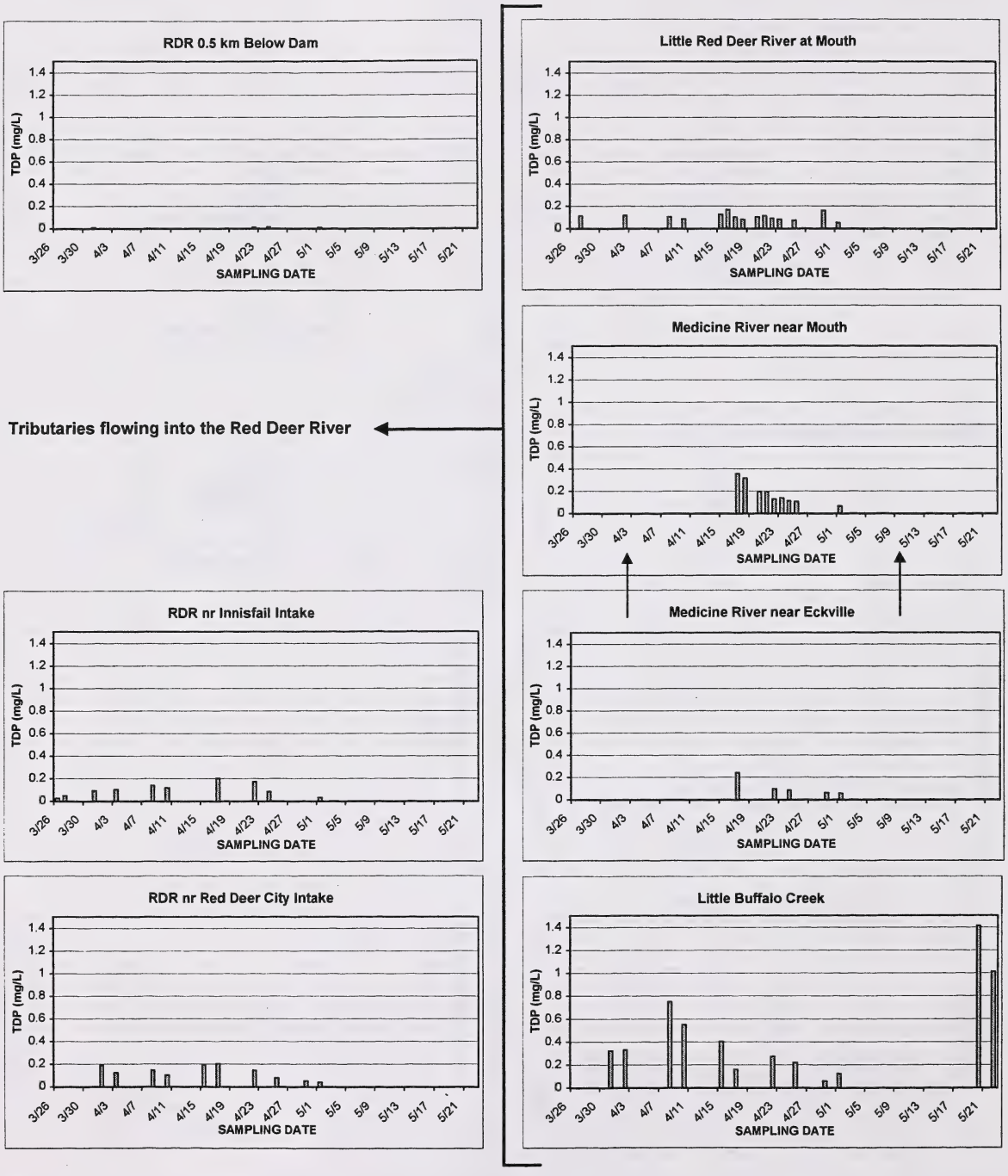


Figure 2-14. Total dissolved phosphorus in the Red Deer River and its tributaries during spring runoff, 1997.

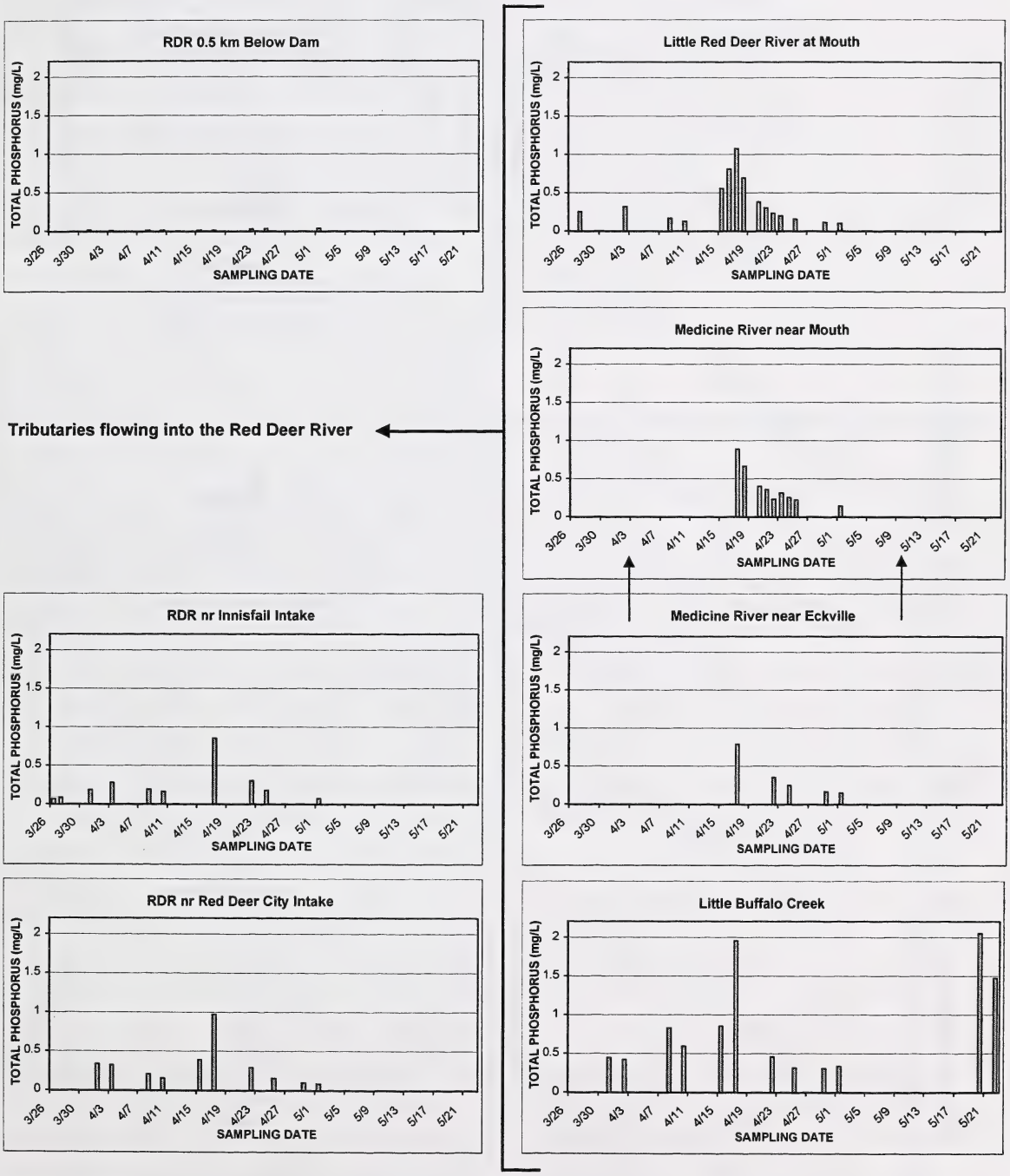


Figure 2-15. Total phosphorus in the Red Deer River and its tributaries during spring runoff, 1997.

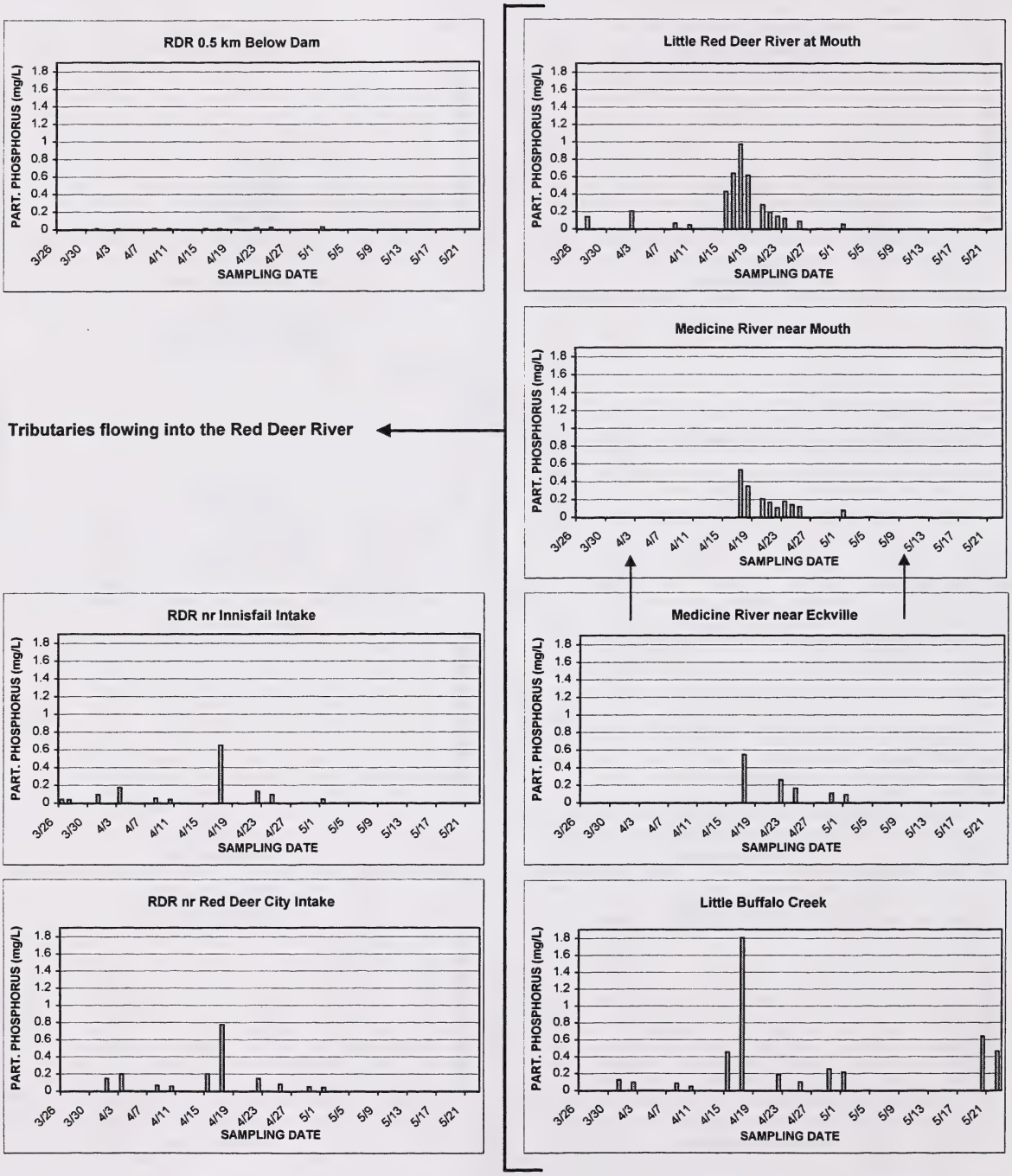


Figure 2-16. Particulate phosphorus in the Red Deer River and its tributaries during spring runoff, 1997.

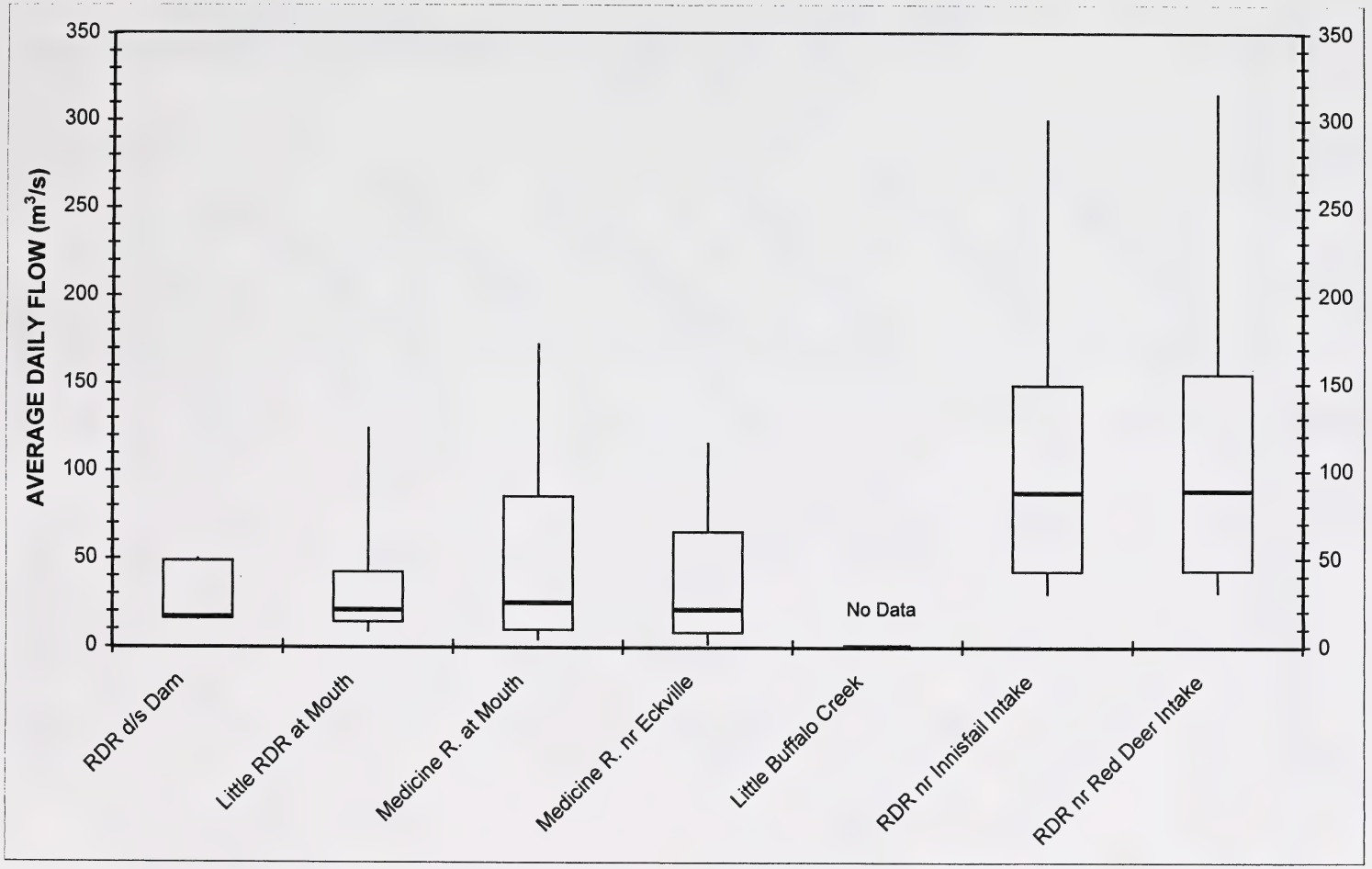


Figure 3-1. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for average daily flow at river and tributary sites.

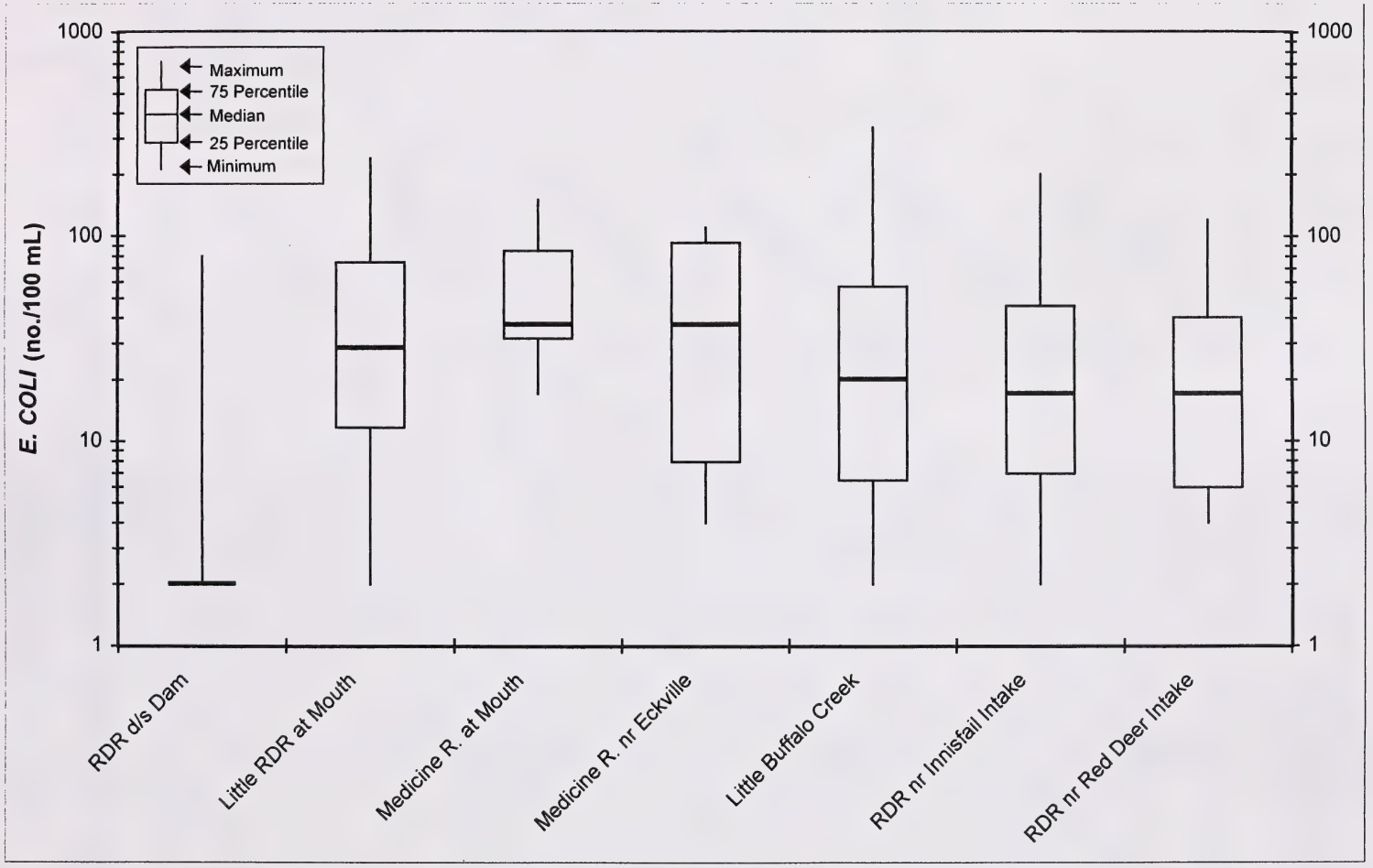


Figure 3-2. Red Deer River during spring runoff, March to May, 1997. Box and Whisker plots for *E. coli* counts at river and tributary sites.

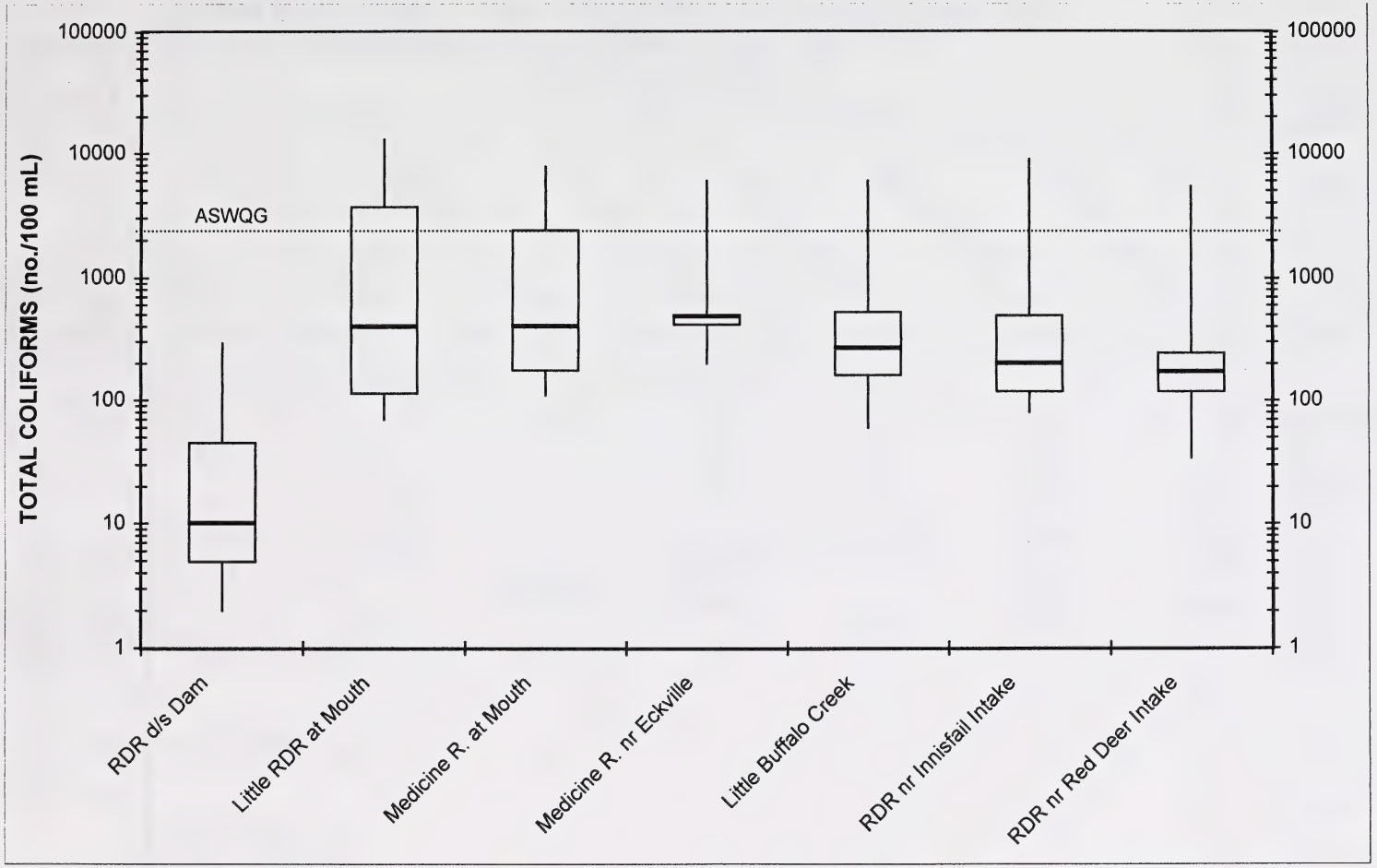


Figure 3-3. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for total coliform counts at river and tributary sites.

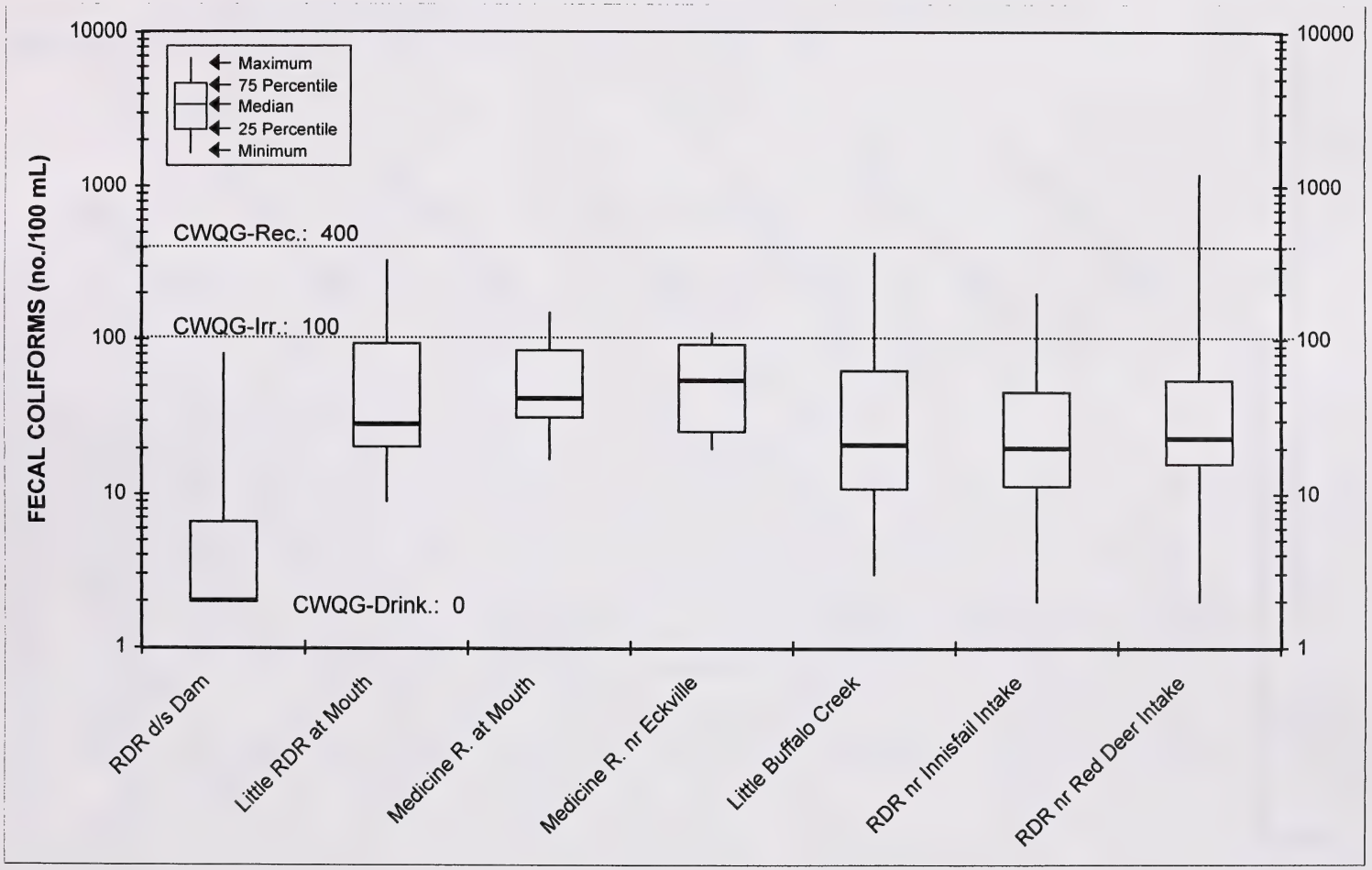


Figure 3-4. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for fecal coliform counts at river and tributary sites.

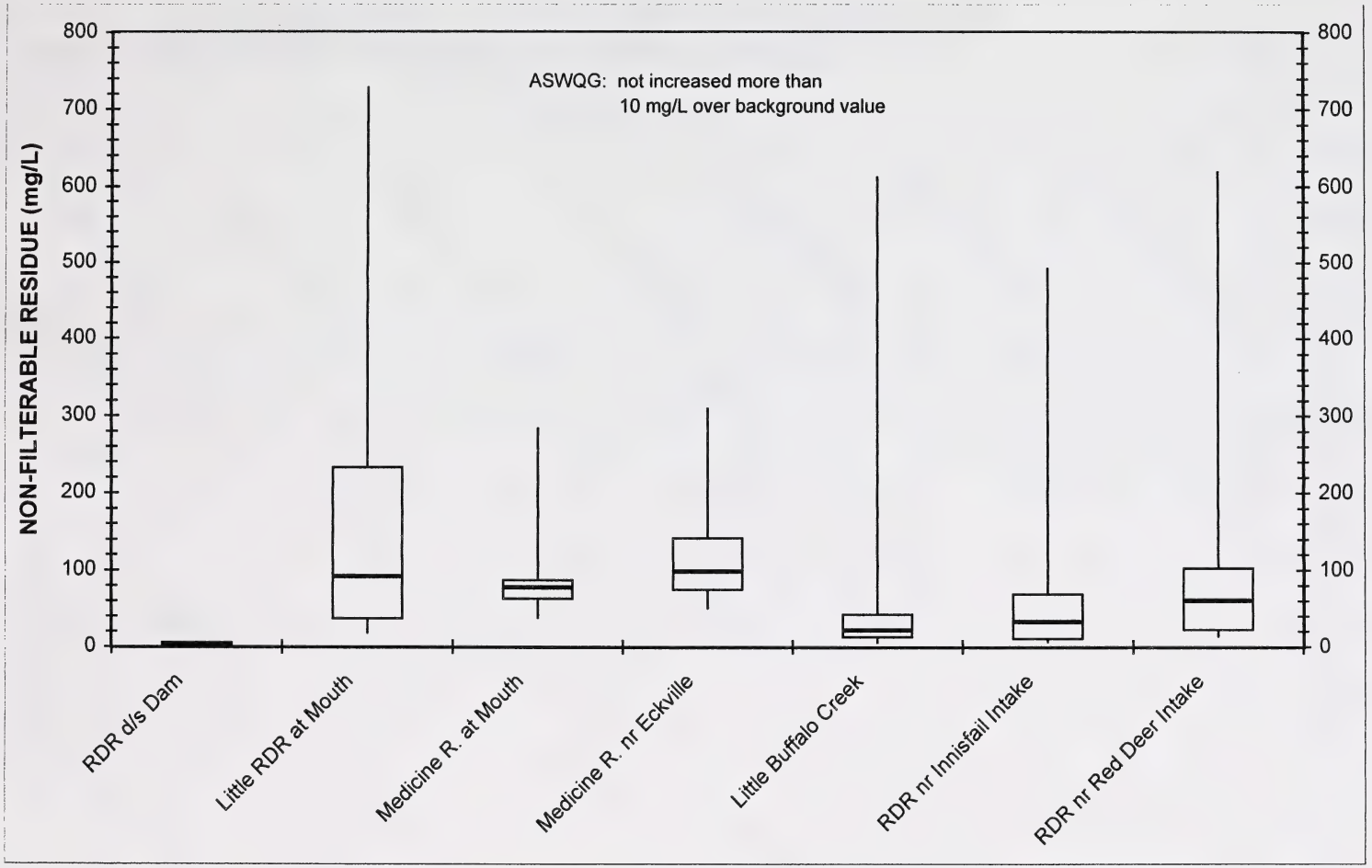


Figure 3-5. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for non-filterable residue at river and tributary sites.

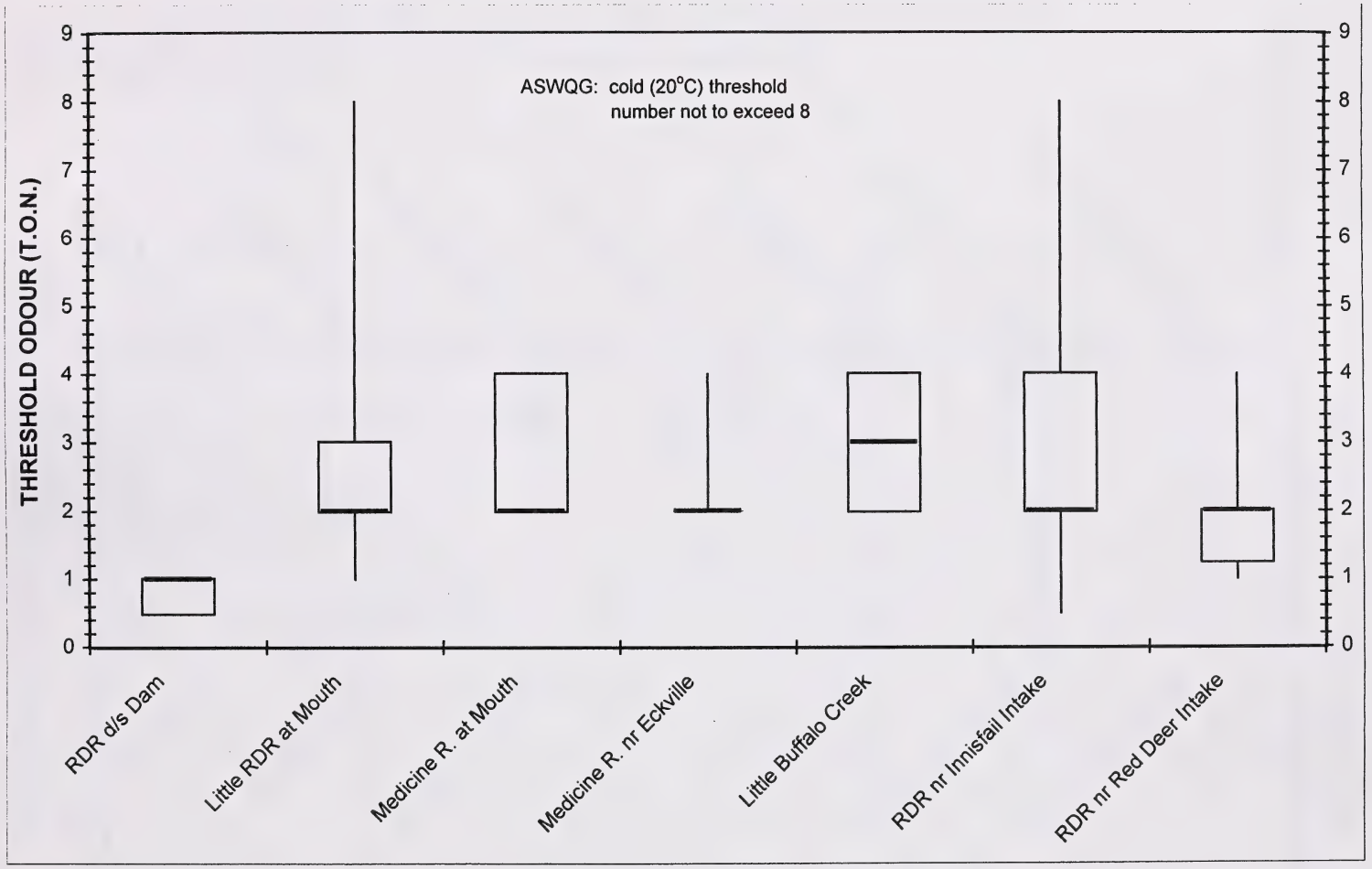


Figure 3-6. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for threshold odour at river and tributary sites.

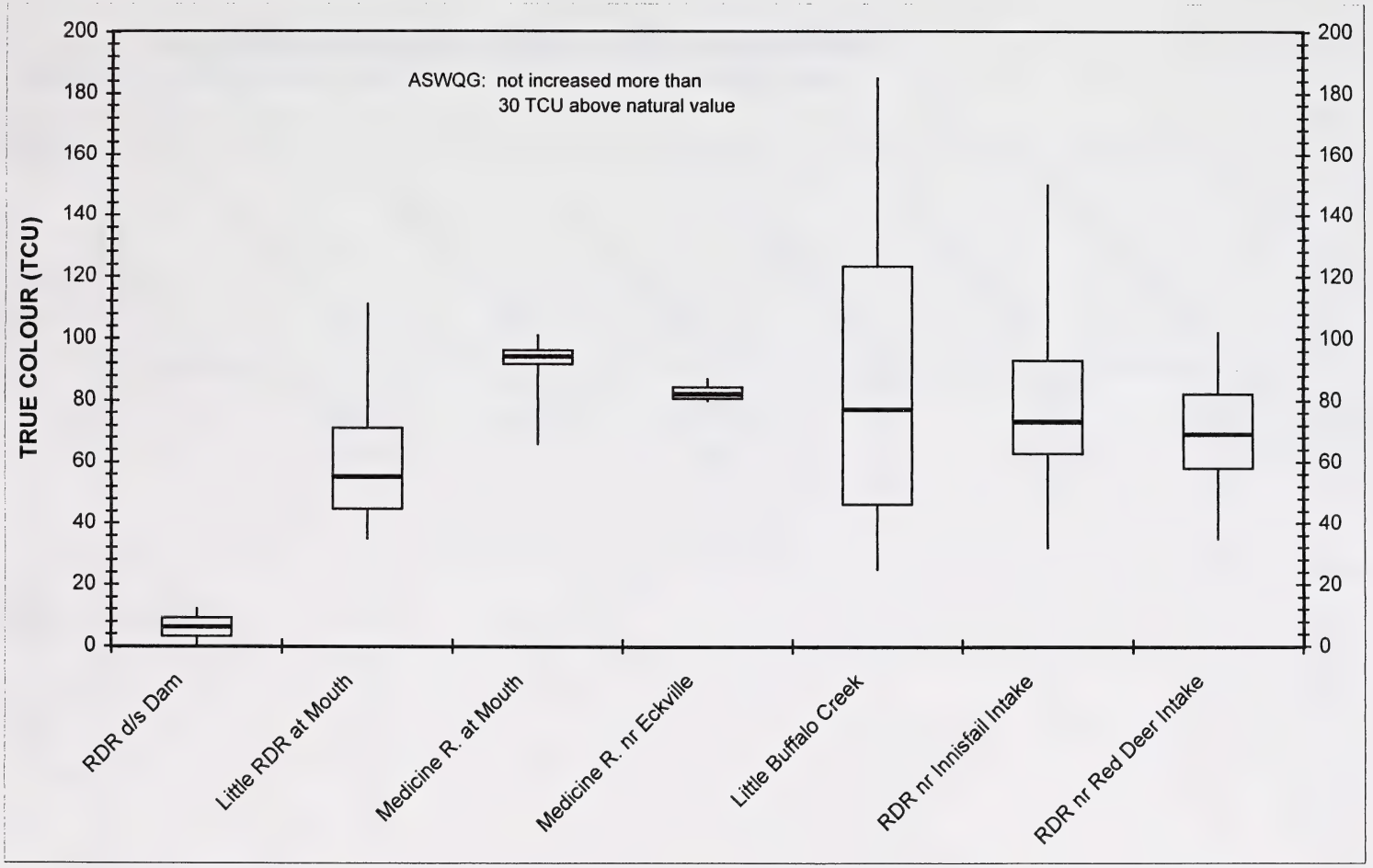


Figure 3-7. Red Deer River during spring runoff, March to May, 1997. Box and Whisker plots for true colour at river and tributary sites.

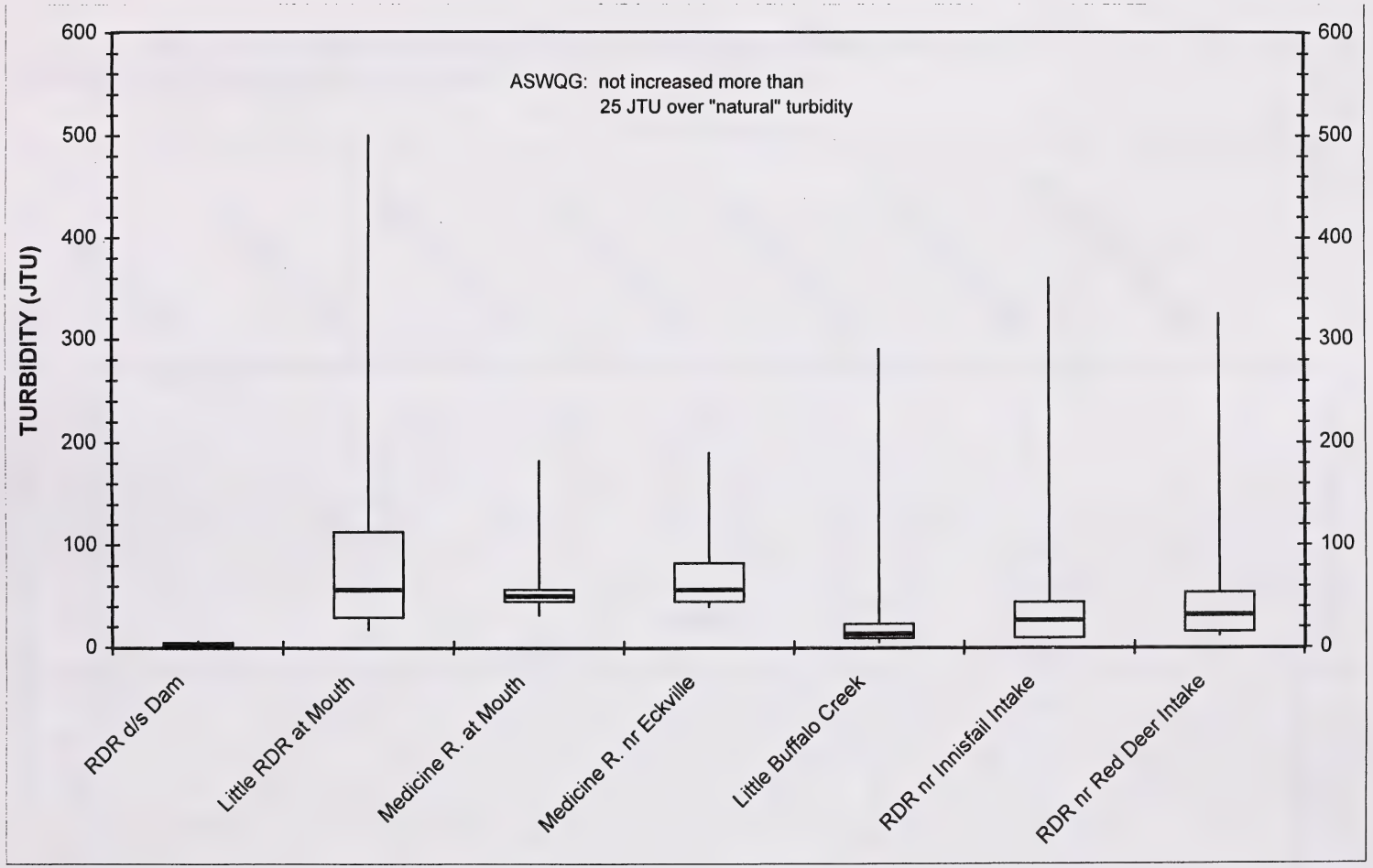


Figure 3-8. Red Deer River during spring runoff, March to May, 1997. Box and Whisker plots for turbidity at river and tributary sites.

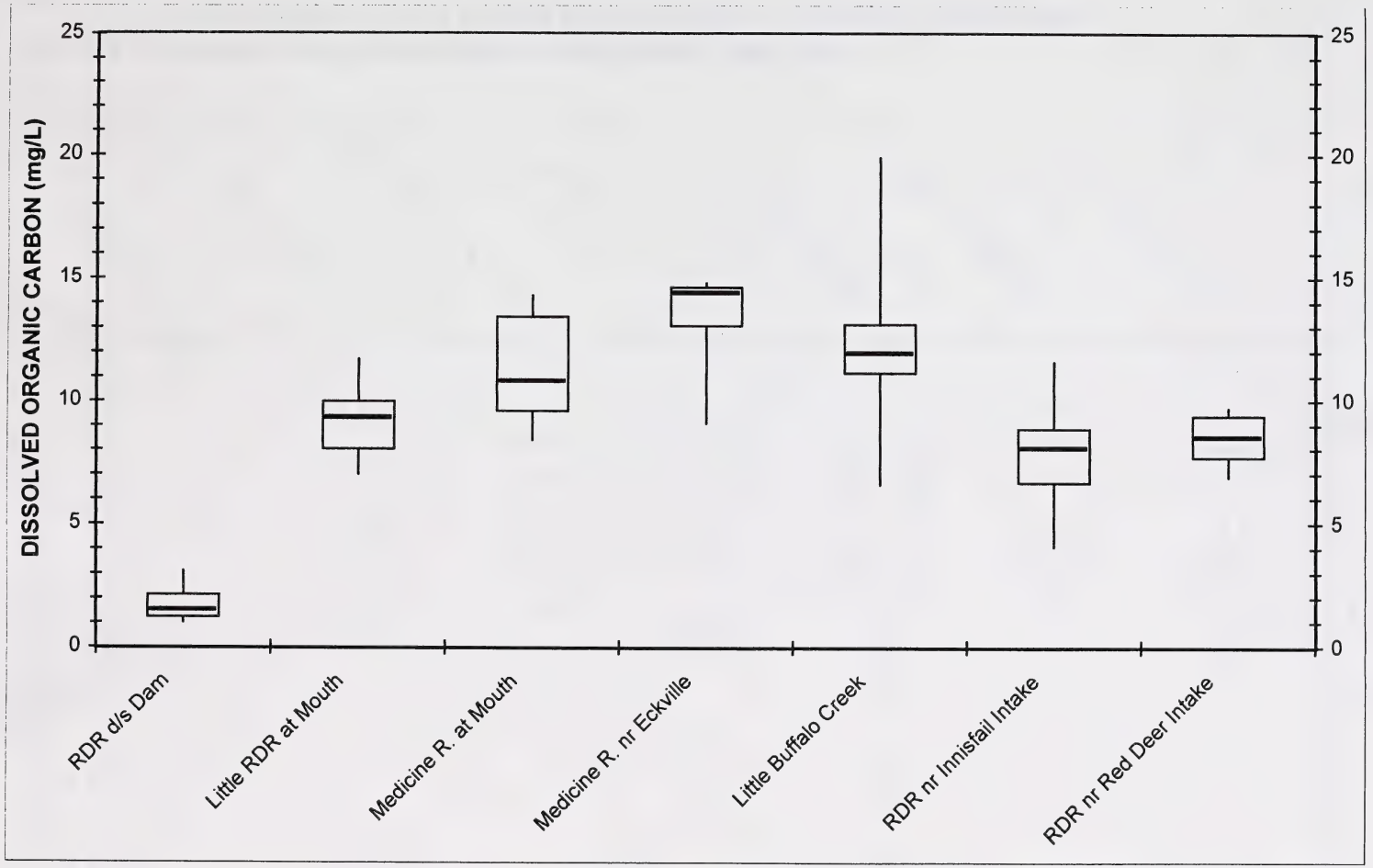


Figure 3-9. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for dissolved organic carbon at river and tributary sites.

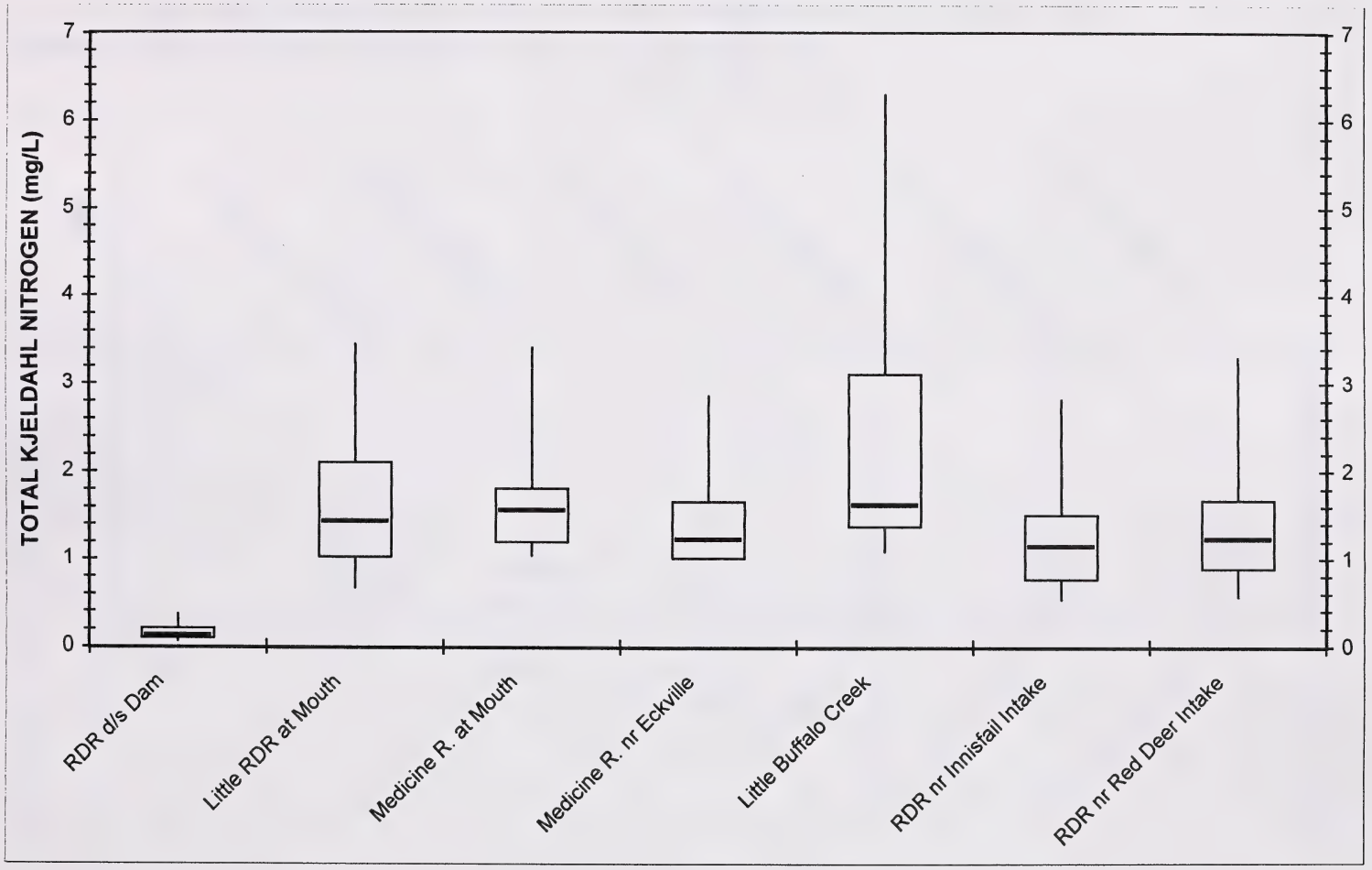


Figure 3-10. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for total Kjeldahl nitrogen at river and tributary sites.

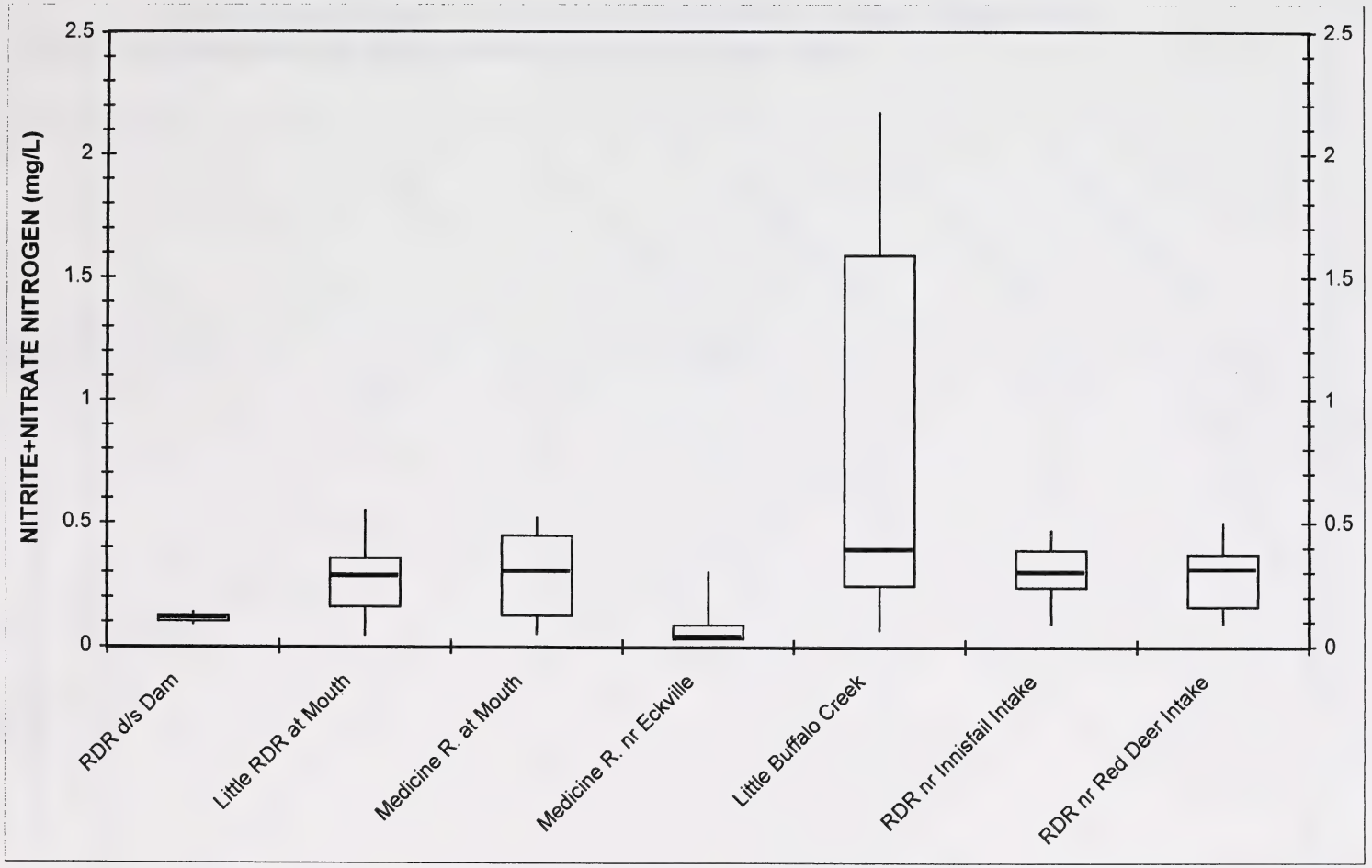


Figure 3-11. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for nitrite+nitrate nitrogen at river and tributary sites.

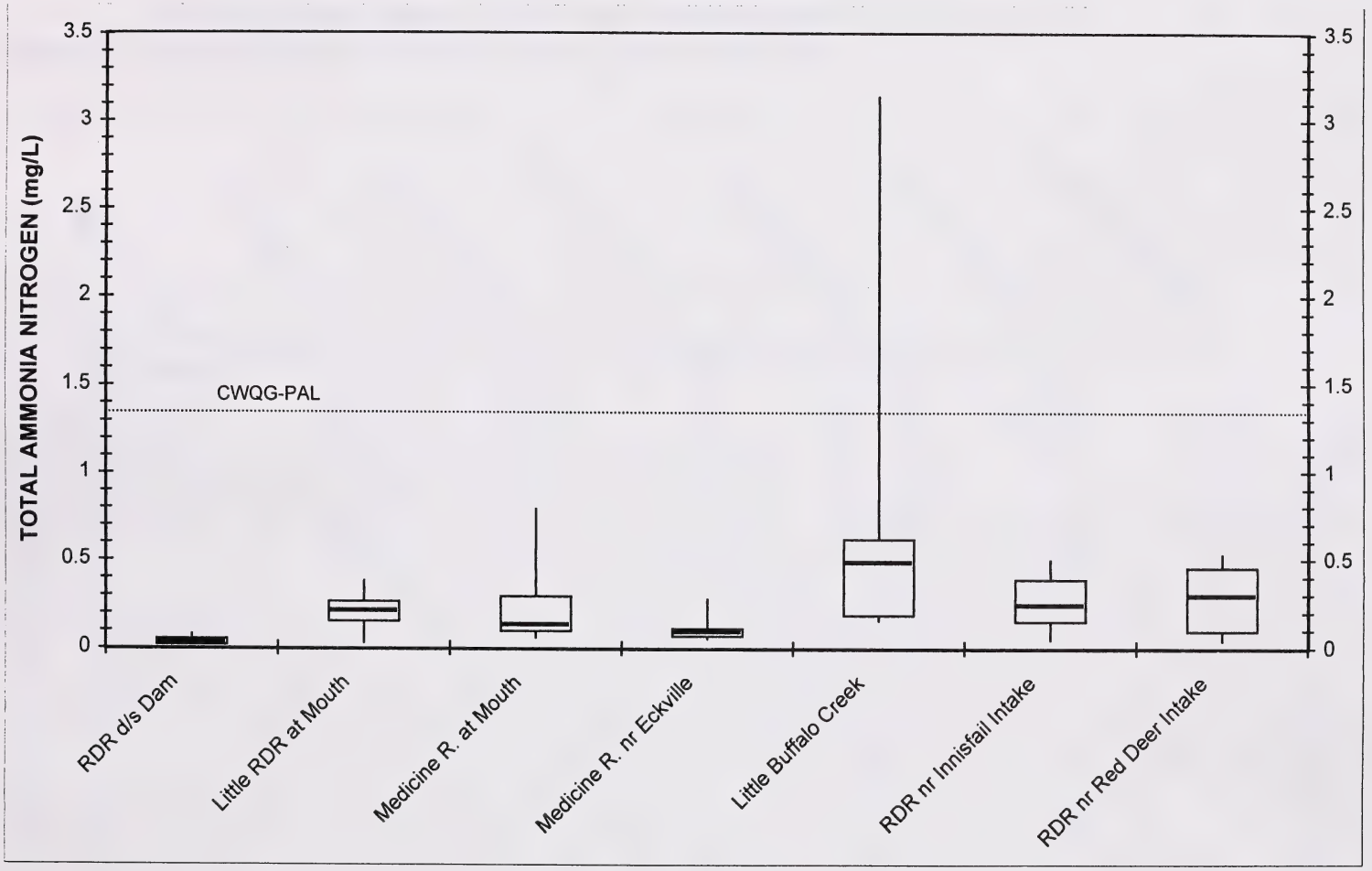


Figure 3-12. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for total ammonia nitrogen at river and tributary sites.

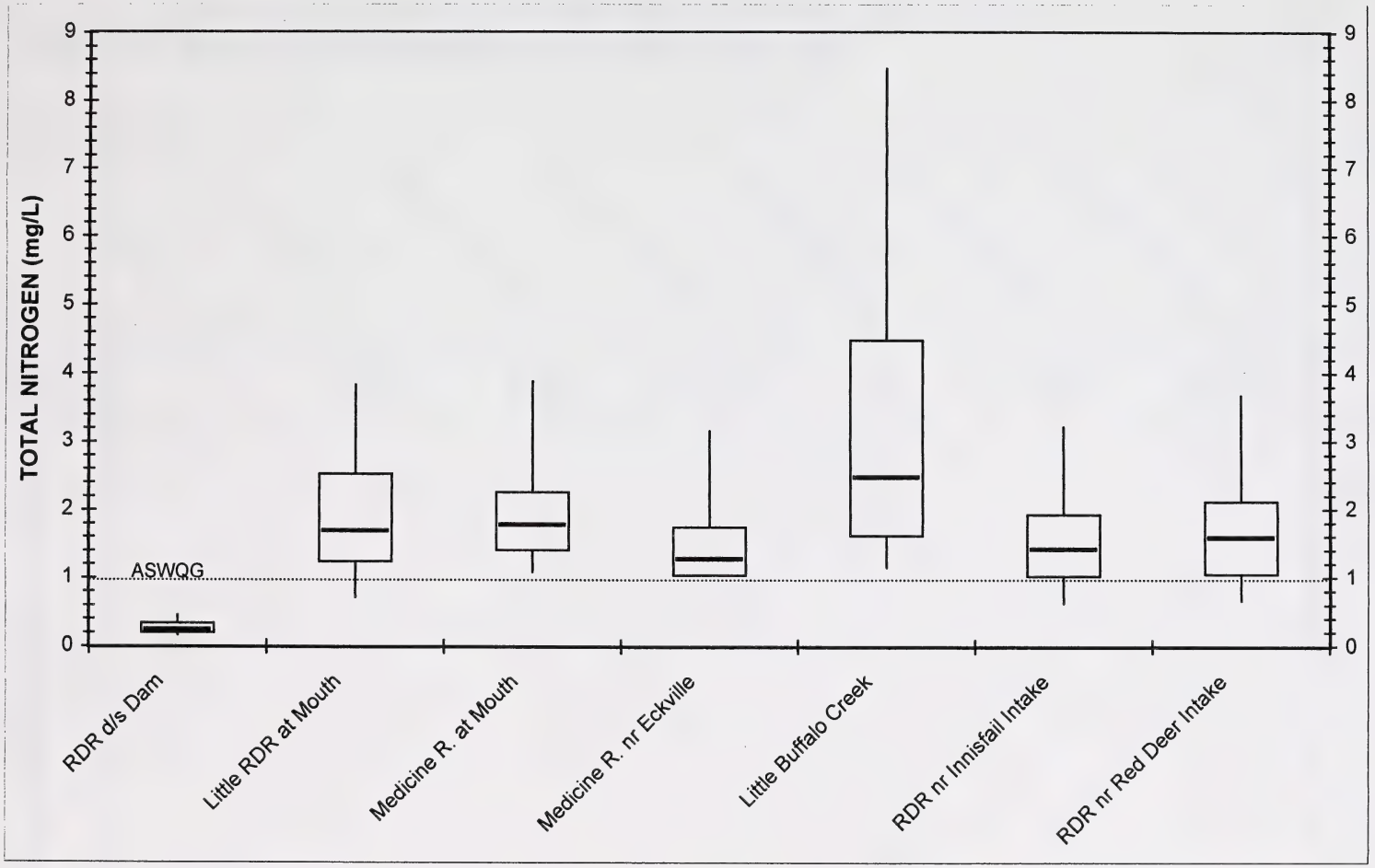


Figure 3-13. Red Deer River during spring runoff, March to May, 1997. Box and Whisker plots for total nitrogen at river and tributary sites.

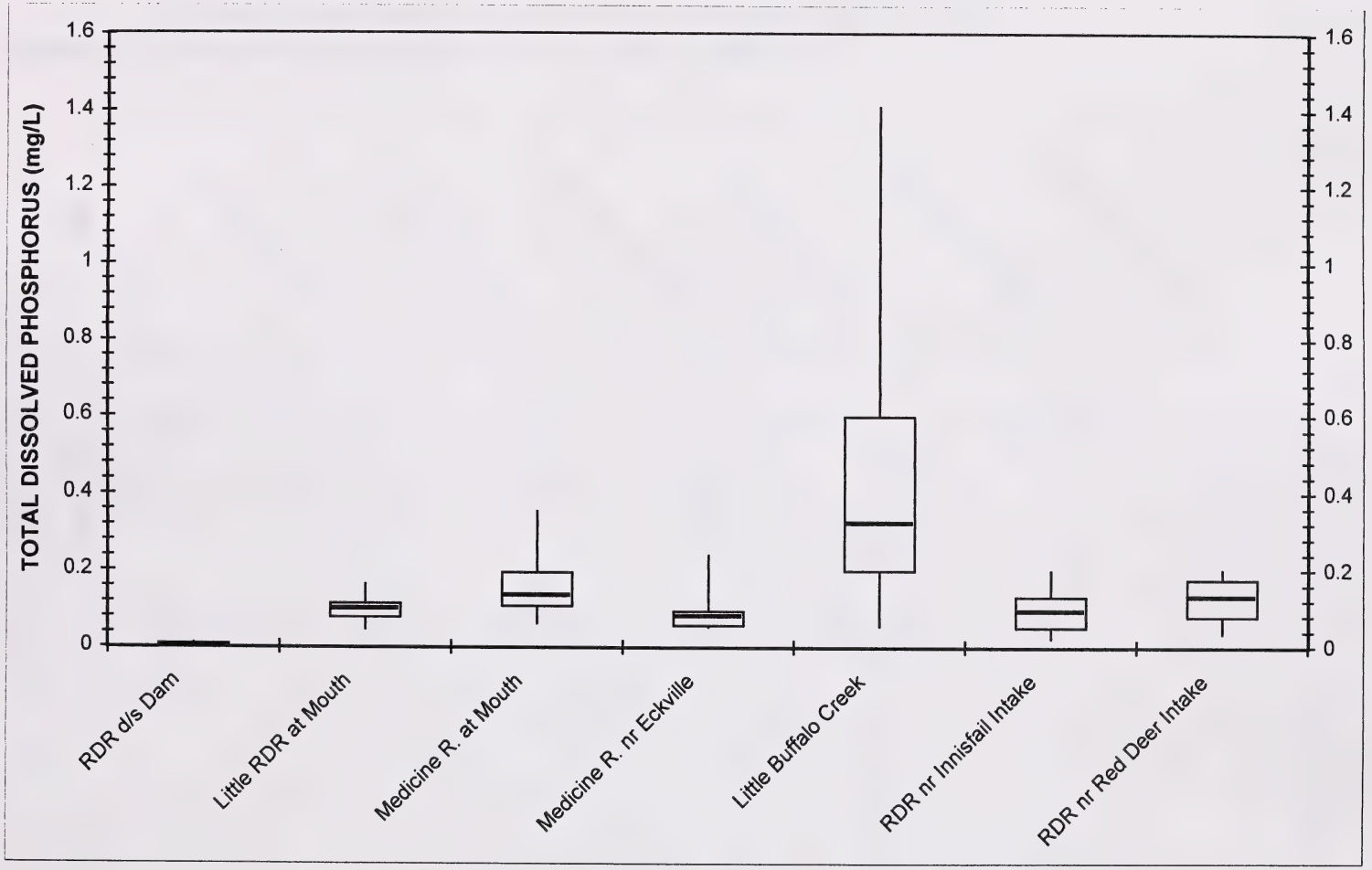


Figure 3-14. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for total dissolved phosphorus at river and tributary sites.

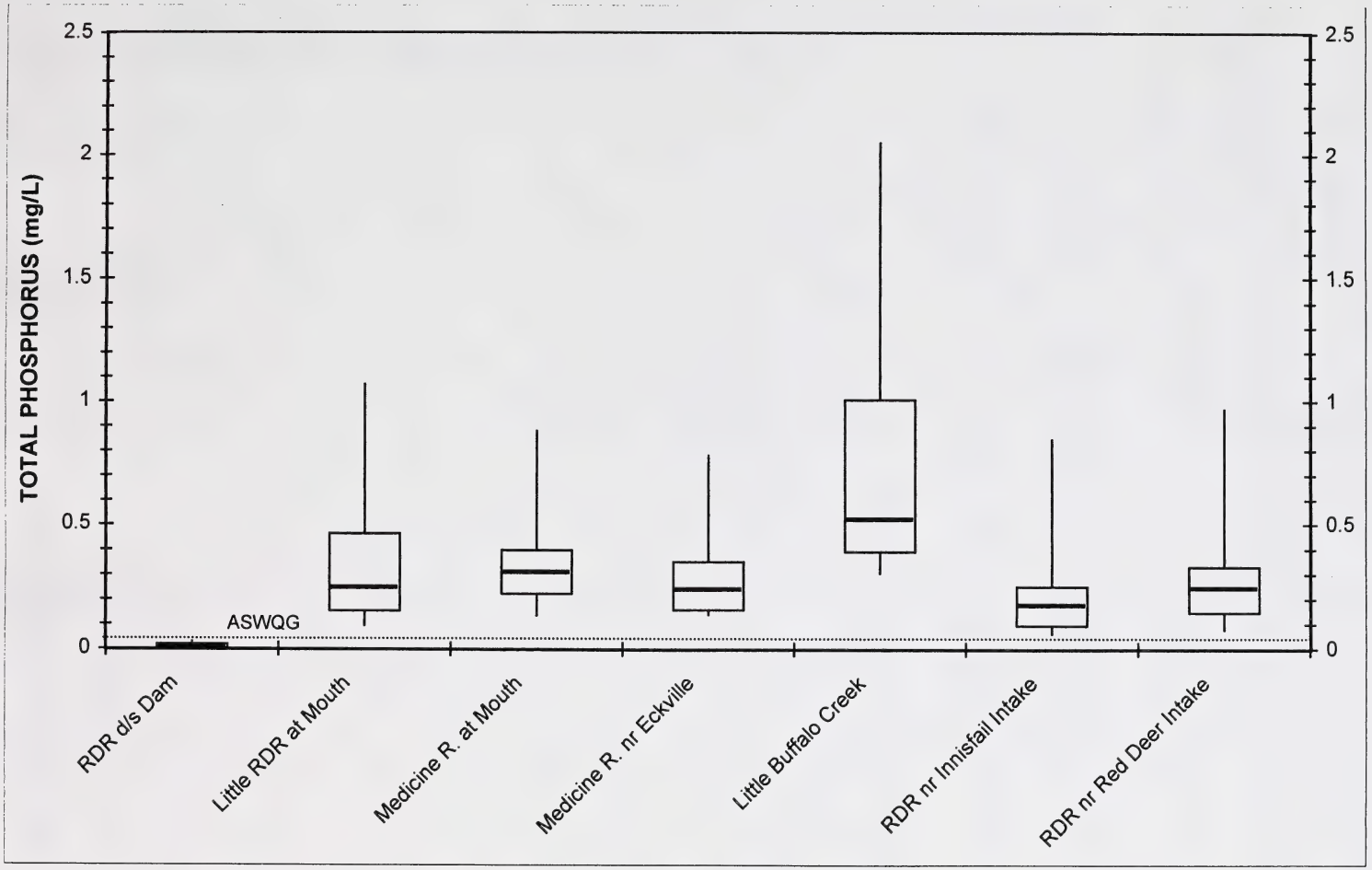


Figure 3-15. Red Deer River during spring runoff, March to May, 1997. Box and Whisker plots for total phosphorus at river and tributary sites.

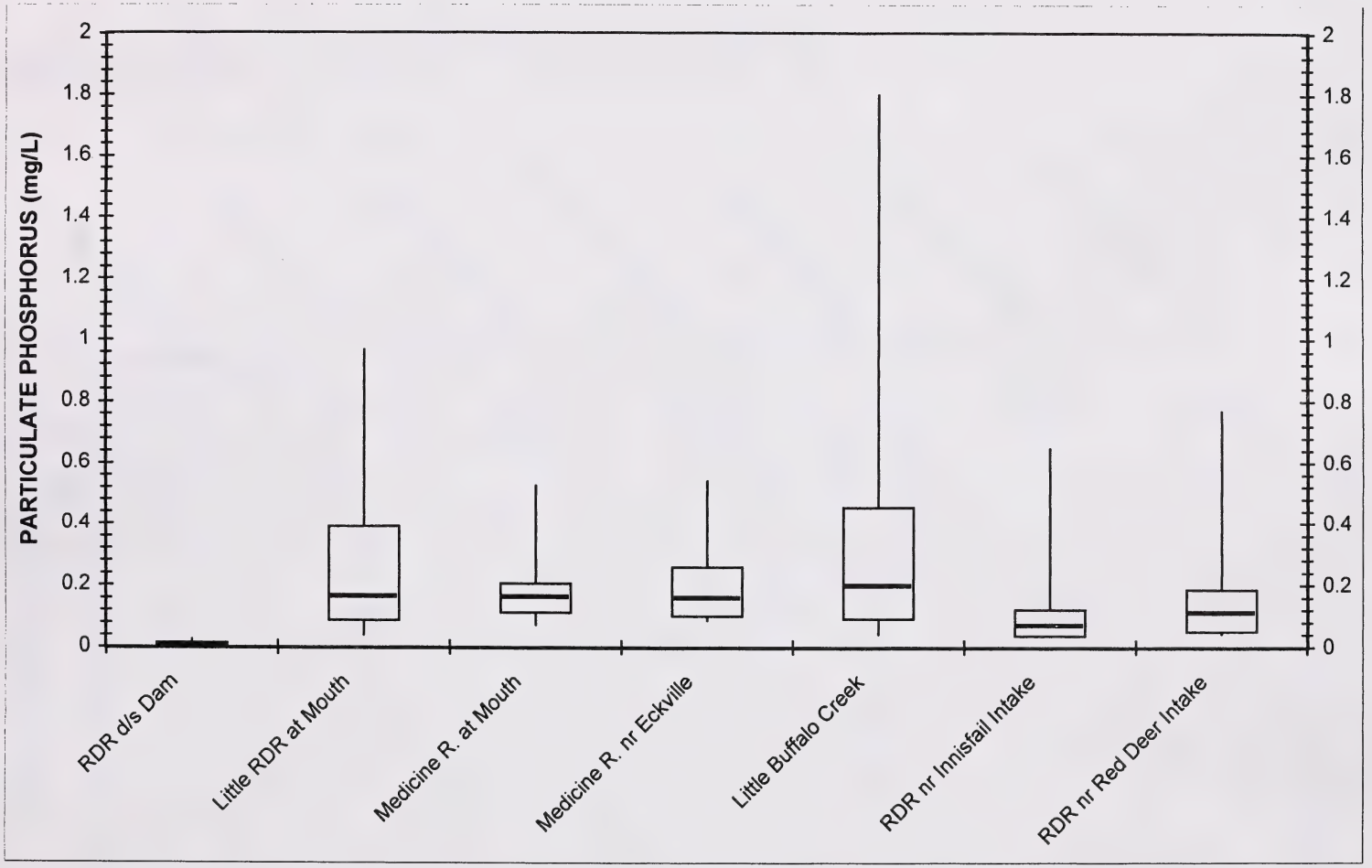


Figure 3-16. Red Deer River during spring runoff, March to May, 1997.
Box and Whisker plots for particulate phosphorus at river and tributary sites.

Appendix A. Chemical treatment required by A. Henday W.T.P. to treat Red Deer River water in April 1997.

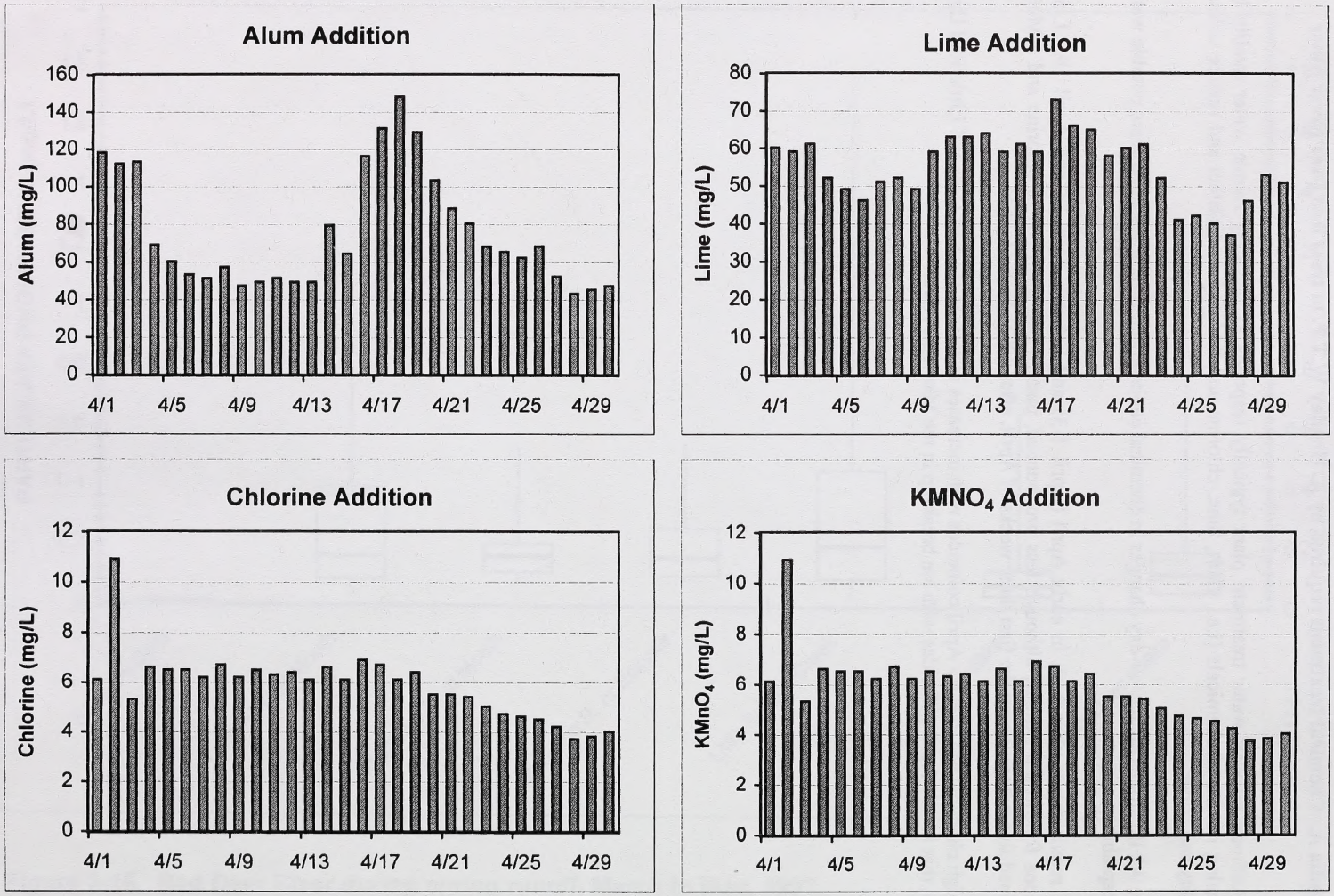
The Anthony Henday water treatment plant typically responds to declining source water quality by increasing its use of chemicals (i.e., alum, lime, chlorine and $KMnO_4$) to disinfect and reduce colour, turbidity and odour.

Figure A1 illustrates the day-to-day changes in chemical concentrations required to produce potable water of acceptable quality.

Alum requirements were high in early April (April 1-3) and between April 15 and April 19. Lime additions followed a similar, although less pronounced, pattern and additions of chlorine and $KMnO_4$ remained steady throughout the first three weeks of April, after which they declined.

The high chemical use in early April coincides with increases in flow in the Red Deer and Little Red Deer rivers; that in mid April coincides with ice break-up in the Medicine River.

Figure A1. Chemical treatment required by A. Henday W.T.P. to treat Red Deer River water in April 1997.



Data Source: Monthly operational and maintenance report from Mountain View Regional Water Service Commission.
Submitted to Air and Water Approvals Division.

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